

## **Copepod Parasites (Crustacea) of Freshwater Fishes in Korea**

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### **ABSTRACT**

Twelve species in five genera of parasitic copepods are recorded from seventeen species of freshwater fishes of Korea. They are *Ergasilus coniformis* n. sp., *Ergasilus ventriosus* n. sp., *E. briani* Markewitsch, *E. peregrinus* Heller, *Neoergasilus japonicus* (Harada) *N. longispinosus* Yin, *N. inflatus* Yin, *N. bullatus* n. sp., *N. angustus* n. sp., *Sinergasilus undulatus* (Markewitsch), *Lernaea cyprinacea* L., and *Lamproglena chinensis* Yü. As the most prevalent parasitic copepod, *Neoergasilus japonicus* is found to parasitize as many as ten species of freshwater fishes in Korea. The fish *Zacco platypus*, from which seven species of parasitic copepods are discovered, turned out to be the most preferred host of the parasitic copepods in this country. Full descriptions are given of the new species and new records of Korea. *Lamproglena chinensis*, an incompletely known species, is also redescribed.

Key words: Parasitic Copepoda, Korea, freshwater fishes

### **INTRODUCTION**

In Korea, the freshwater fishes are economically important, with various species being cultured in culture ponds and reservoirs. In spite of these and the fact that crustacean parasites are known to give harmful effects on the fishes, very few studies have been made on these fish-parasitic copepods. According to Kim (1998), only three species of copepods are reported from Korea as

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parasites of freshwater fishes: *Neoergasilus longispinosus* Yin, 1956, *Lamproglena chinensis* Yü, 1937 and *Lernaea cyprinacea* L., 1758.

In 2002 we collected copepods parasitic on freshwater fishes from various static and running water in Korea. As the result of the examination of the collected copepods, 12 species in five genera were identified, as the following list. This paper is to report these copepods.

Subclass Copepoda

Order Poecilostomatoida

Family Ergasilidae

1. *Ergasilus coniformis* n. sp. from *Zacco platypus* (Temminck and Schlegel)
2. *Ergasilus ventriosus* n. sp. from *Acanthorhodeus macropterus* Bleeker, *Zacco platypus*, *Rhodeus nothatus* Nichols and *Rhodeus uyekii* (Mori)
3. *Ergasilus briani* Markewitsch, 1933 from *Squalidus chankaensis tsuchigae* (Jordan and Hubbs), *Hemiculter eigenmanni* (Jordan and Metz), *Odontovutis interrupta* Iwata and Jeon, *Carassius auratus* (L.) and *Pseudorasbora parva* (Temminck and Schlegel).
4. *Ergasilus peregrinus* Heller, 1865 from *Siniperca scherzeri* Steindachner
5. *Neoergasilus japonicus* (Harada, 1930) from *Carassius auratus* (L.), *Siniperca scherzeri*, *Zacco platypus*, *Pseudorasbora parva*, *Lepomis macrochirus* Lafinesque, *Hemiculter eigenmanni*, *Cyprinus carpio* L., *Micropterus salmoides* (Lacépède), *Squalidus japonicus coreanus* (Berg) and *Pungtungia herzi* Herzenstein.
6. *Neoergasilus longispinosus* Yin, 1956 from *Carassius auratus*, *Pseudorasbora parva*, *Hemiculter eigenmanni* and *Culter brevicauda* (Gunther).
7. *Neoergasilus inflatus* Yin, 1956 from *Zacco platypus*.
8. *Neoergasilus bullatus* n. sp. from *Zacco platypus*.
9. *Neoergasilus angustus* n. sp. from *Zacco platypus*, *Pseudorasbora parva* and *Micropterus salmoides*.
10. *Sinergasilus undulatus* (Markewitsch, 1940) from *Carassius auratus*.

Order Cyclopoida

Family Lernaeidae

11. *Lernaea cyprinacea* L., 1758 from *Carassius auratus*, *Pseudorasbora parva*, *Zacco platypus*, *Lepomis macrochirus*, *Channa arga* (Cantor), *Cyprinus carpio*, *Micropterus salmoides* and *Hemiculter eigenmanni*.
12. *Lamproglena chinensis* Yü, 1937 from *Channa arga*.

## MATERIALS AND MEHTODS

The freshwater fishes were collected using the casting net and gill net. The collected fishes were fixed immediately with 5% formalin for about half an hour, and then, preserved in 80% alchohol. In the laboratory, the body surface and gills of the collected fishes were searched for copepods and the copepods were carefully removed under the dissecting microscope. The identification of the

fishes and usage of their scientific names were based on Kim (1997). Before dissection of the copepods, the specimens were soaked in lactic acid for at least 30 minutes. All drawings were made with the aid of a drawing tube attached to microscope. Since no male of these copepods was discovered, only females are dealt with in the following descriptions. Type specimens will be deposited in the U. S. National Museum of Natural History, Smithsonian Institution, Washington D.C., USA.

## DESCRIPTION OF SPECIES

Order Poecilostomatoida 천장입요각목

Family Ergasilidae 낫벌레과

Genus *Ergasilus* Nordmann 1832 낫벌레속

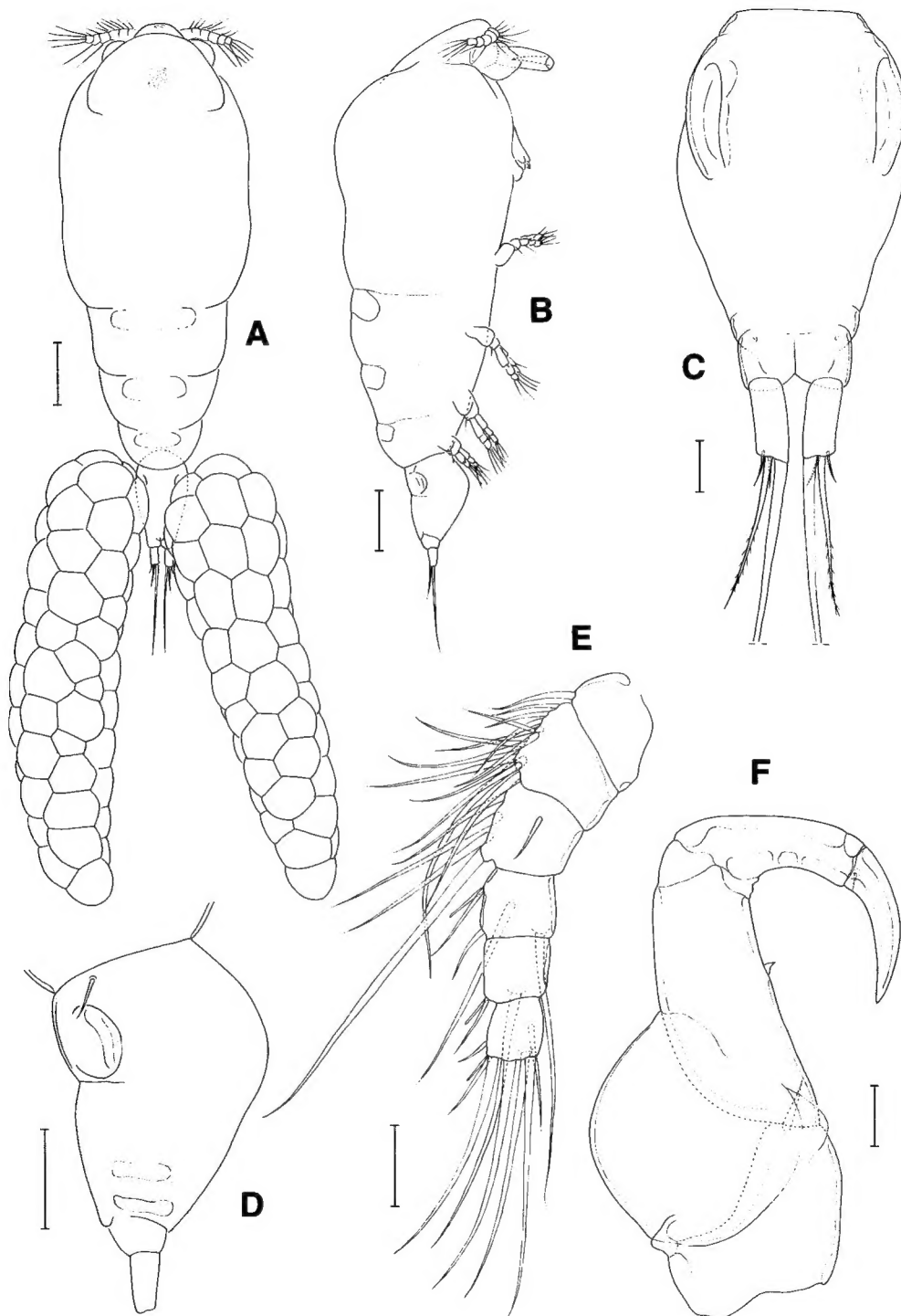
***Ergasilus coniformis* n. sp.** 피라미낫벌레 (신칭) (Figs. 1 and 2)

**Material examined.** Fifty ♀♀ removed from gills of *Zacco platypus*, Kobok Reservoir in Seomyeon, Yeongi-gun, Choongnam (36° 36'N, 127° 14'E), 31 July 2002. Holotype (♀) and paratypes (26 ♀♀) will be deposited in the U. S. National Museum of Natural History, Smithsonian Institution, Washington D. C. Dissected paratypes (2 ♀♀) and the remaining specimens are kept in the collection of the senior author.

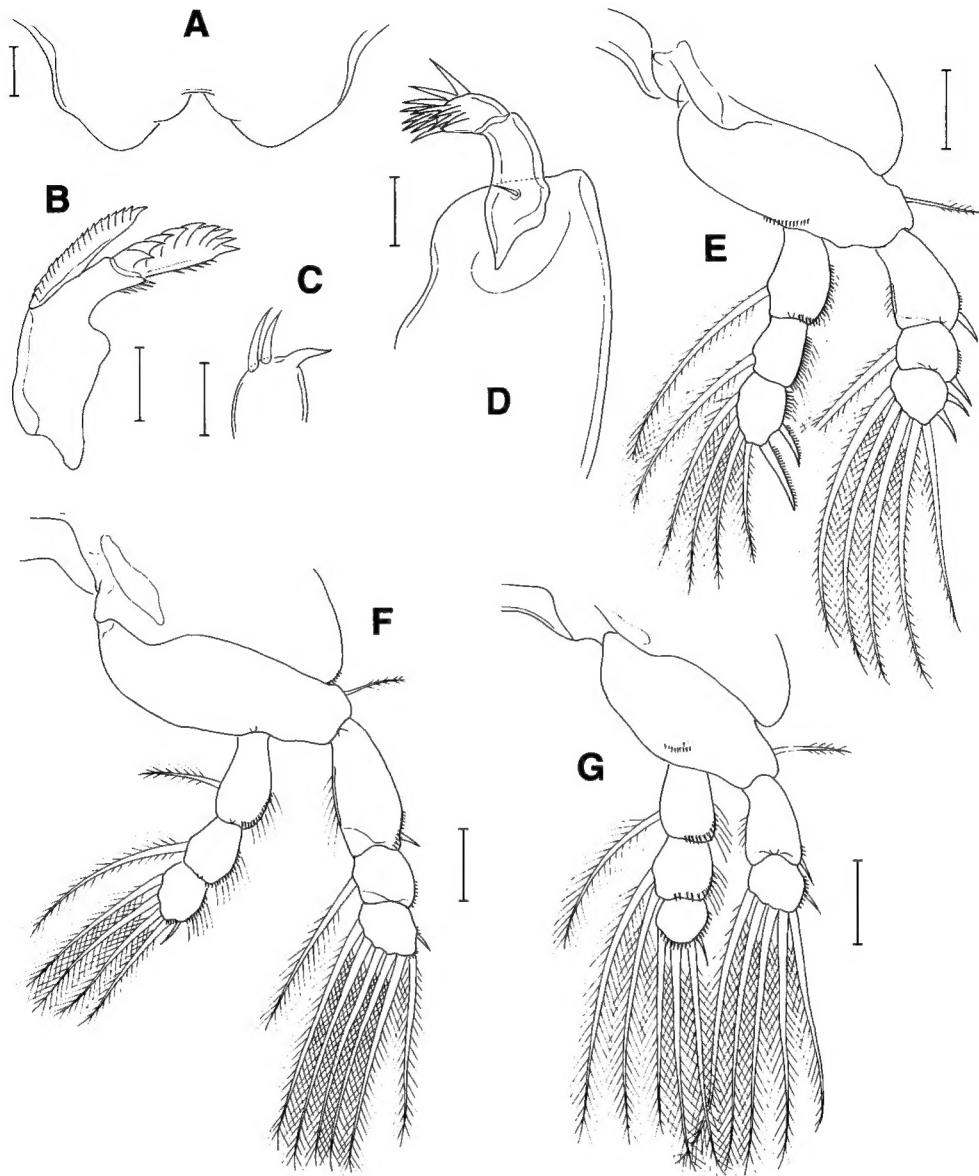
**Other material examined.** All from gills of the same species as the type material: 6 ♀♀ from Miho Stream in Kangnae-myeon, Cheongwon-gun, Choongbuk (36° 37'N, 127° 20'E), 15 July 2002; numerous specimens from Daeyool Reservoir in Kumgoo-myeon, Kimje, Jeonbuk (35° 47'N, 127° 02'E), 8 August 2002; 102 ♀♀ from Sinpoong Reservoir in Jibo-myeon, Yecheon-gun, Kyeongbuk (36° 33'N, 128° 27'E), 3 August 2002.

**Female.** Body (Fig. 1A, B) 950 µm long, distinctly tapering posteriorly. Prosoma cylindrical (as wide as deep) or depressed dorsoventrally. Cephalothorax usually longer than wide but in fewer cases wider than long. Cephalothorax and 3 pedigerous somite delimited by faint dorsal lines or completely fused (in fully grown adults) to form a cylinder. Three prosomal pedigerous somites each with rudimentary epimera. Antennary area discriminable but depressed. Urosome (Fig. 1C, D) small, ovoid, occupying only about 20% length of whole body, deeper than wide, consisting of fused fifth pedigerous, genital and anterior abdominal somites, and indistinctly delimited pre-anal and anal somites, with strongly convex ventral margin and weakly concave dorsal margin; in lateral view, only anal somite discriminable from rest of urosome, and rudimentary epimera of 2 pre-anal somites visible. Caudal ramus 35 × 14 µm (ratio 2.50 : 1), with 4 terminal setae; second longest setae weakly plumous distally, other setae naked. Egg sac variable in size, usually tapering distally, 1019 × 212 µm in dissected specimen (Fig. 1A).

Antennule (Fig. 1E) 6-segmented, 98 µm long; armature formula 1, 13, 5, 4+1 aesthetasc, 2+1 aesthetasc, and 7+1 aesthetasc; all setae naked. Antenna (Fig. 1F) 4-segmented; first segment 54 × 61 µm, wider than long, with 1 distal seta; second segment 91 × 38 µm, but proximal half of this segment and distal part of first segment together producing large, outer expansion (77 µm wide in this area), with small, conical seta on inner margin; third segment about 2/3 length of second segment and unarmed; terminal claw as long as third segment, with 1 small proximal seta.



**Fig. 1.** *Ergasilus coniformis* n. sp., female. A, habitus, dorsal; B, same, lateral; C, urosome, dorsal; D, same lateral; E, antennule; F, antenna. Scales: A, B, 0.1 mm; C, E, F, 0.02 mm; D, 0.05 mm.



**Fig. 2.** *Ergasilus coniformis* n. sp., female. A, labrum; B, mandible; C, maxillule; D, maxilla; E, leg 1; F, leg 2; G, leg 4. Scales: A-D, 0.01 mm; E-G, 0.02 mm.

Labrum (Fig. 2A) with bilobed posterior margin, each lobe tapering; median incision prominent. Mandible (Fig. 2B) bearing posterior and distal blades. Maxillule (Fig. 2C) lobate bearing distally 2 setae and 1 process. Maxilla (Fig. 2D) 2-segmented; first segment unarmed; second segment divided by faint delimitation into proximal and distal parts, with 1 seta on proximal part and spinules on distal part.

Legs 1-3 with 3-segmented exopod and endopod. Leg 4 with 2-segmented exopod and 3-segmented endopod. Endopodal segments of legs 1-4 with spinules on outer margin. Armature formula of legs 1-4 as follows:

Leg 1:	coxa 0-0;	basis 1-0;	exp. I-0; I-1; II, 5;	enp. 0-1; 0-1; II, 4.
Legs 2 & 3:	coxa 0-0;	basis 1-0;	exp. I-0; 0-1; I, 6;	enp. 0-1; 0-1; I, 4.
Leg 4:	coxa 0-0;	basis 1-0;	exp. I-0; I, 5;	enp. 0-1; 0-2; I, 3.

Leg 5 represented by a seta on anterolateral part of urosome (Fig. 1D).

**Male.** Undiscovered.

**Etymology.** The specific name *coniformis* is derived from the reversed conical form of body of the new species.

**Remarks.** *Ergasilus coniformis* n. sp. resembles *Pseudergasilus zacconis* described by Yamaguti (1936) from *Zacco platypus*, the same species of fish host as for the new species. Both species have in common the fused or incompletely delimited body somites, the reversed conic body form, the single seta on the second segment of legs 2 and 3, and the single seta on the first antennular segment. The definition of the genus *Pseudergasilus* made by Yamaguti seems not clear. He presumably considered the fusion of body somites and the reduction or absence of leg 5 as the diagnostic characters of his genus. However, on the basis of our specimens, the degree of the fusion of body somites is depended on the growth state, and the reduction or absence of leg 5 is not a sole trait of *Pseudergasilus*. Moreover, a new species to be described next, belonging apparently to *Ergasilus*, is very similar to this species. Therefore, we consider *Pseudergasilus* as a synonym of *Ergasilus*.

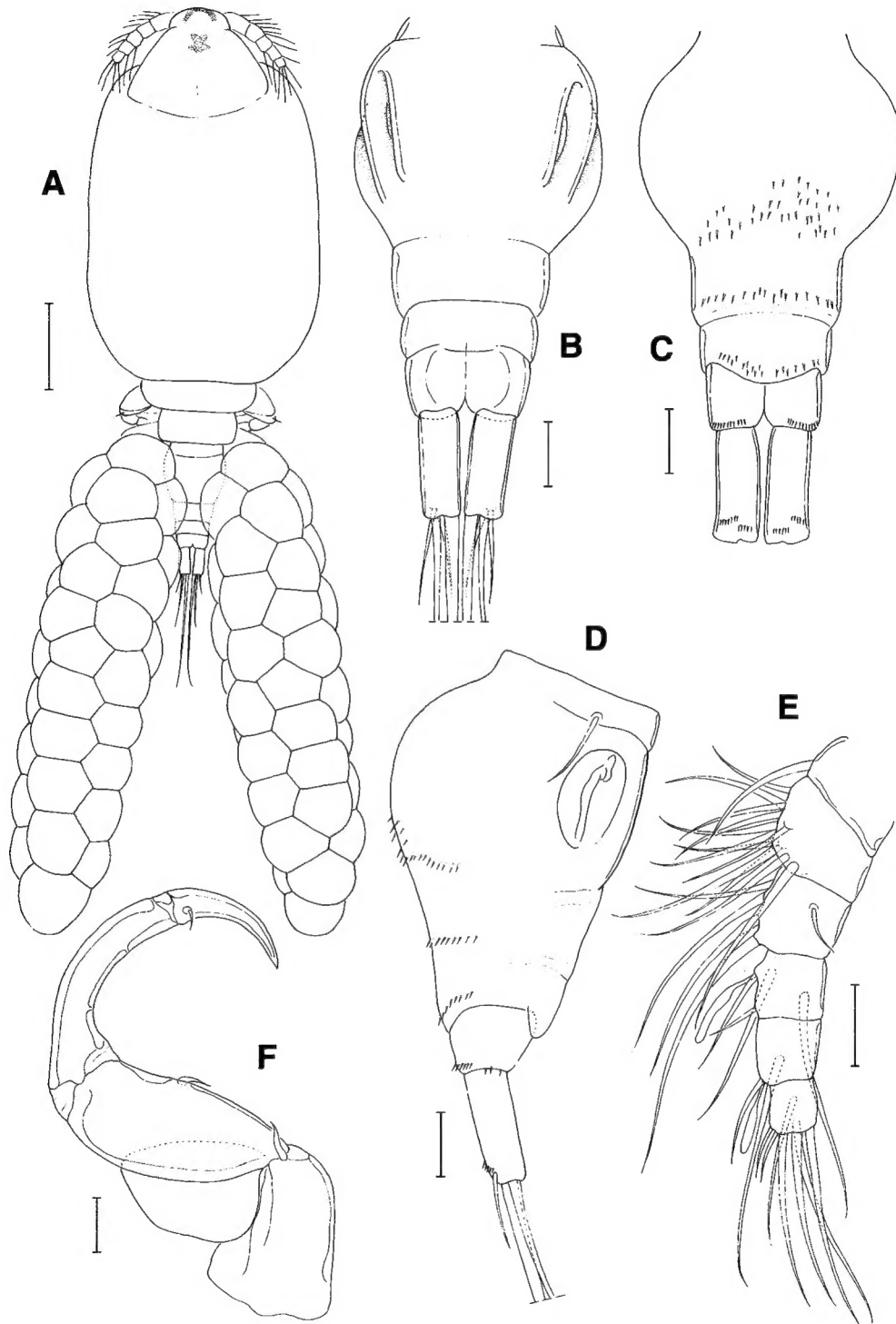
There are several discrepancies between our specimens and Yamaguti's species, now *Ergasilus zacconis* (Yamaguti, 1936). In *E. zacconis*, the terminal exopodal segment of leg 1 is armed with 2 spines and 4 setae (2 spines and 5 setae in *E. coniformis*), the first exopodal segment of leg 4 is unarmed (armed with 1 outer spine in *E. coniformis*), the second endopodal segment of the latter armed with only a single seta (armed with 2 setae in *E. coniformis*), and no leg 5 is present (represented by a single seta in *E. coniformis*). We consider these differences are important, preventing them from a synonymic treatment.

It is notable that there are two body forms of this species, one with cylindrical cephalothorax and the other with dorsoventrally flat cephalothorax. We failed to find more significant differences between the two forms.

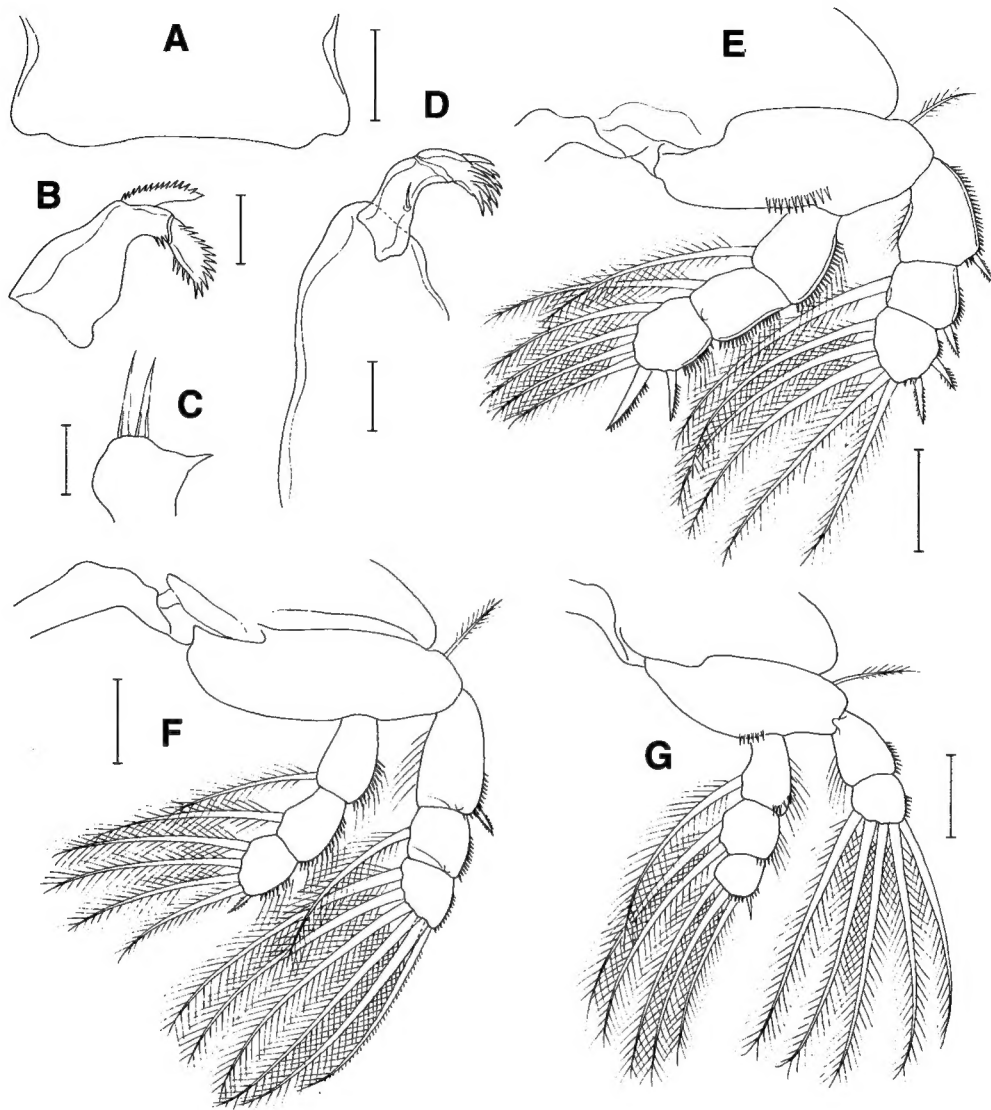
***Ergasilus ventriosus* n. sp. 배불뚝뚝벌레 (신칭) (Figs. 3 and 4)**

**Material examined.** Twenty ♀♀ removed from gills of *Acanthorhodeus macropterus*, Jinyang Lake in Sacheon, Kyeongnam, (35° 10'N, 128° 00'E), 5 August 2002. Holotype (♀) and paratypes (13 ♀♀) will be deposited in the U. S. National Museum of Natural History, Smithsonian Institution, Washington D.C. Dissected paratypes (2 ♀♀) and the remaining specimens are kept in the collection of the senior author.

**Other material examined.** 1) from gills of *Zacco platypus*: 82 ♀♀ from Kobok Reservoir in Yeongi-gun, Choongnam (36° 36'N, 127° 14'E), 31 July 2002; numerous ♀♀ from a stream at Samheung-ri, Yangdo-myeon, Kanghwa-do (37° 41'N, 126° 25'E), 29 July 2002; 52 ♀♀ from



**Fig. 3.** *Ergasilus ventriosus* n. sp., female. A, habitus, dorsal; B, urosome, dorsal; C, same, ventral; D, same, lateral; E, antennule; F, antenna. Scales: A, 0.1 mm; B-F, 0.02 mm.



**Fig. 4.** *Ergasilus ventriosus* n. sp., female. A, labrum; B, mandible; C, maxillule; D, maxilla; E, leg 1; F, leg 2; G, leg 4. Scales: A, E-G, 0.05 mm; B-D, 0.01 mm.

Yoogucheon, Yoogu, Kongju (36°38'N, 126°59'E), 30 July 2002; 2) from gills of *Rhodeus nothatus*: 4 ♀♀ from Jinyang Lake in Sacheon, Kyeongnam (35°10'N, 128°00'E), 5 August 2002; 3) from gill of *Rhodeus uyekii*: 1 ♀ from Juam Dam, Songkwang-myeon, Sooncheon (35°05'N, 127°15'E), 7 August 2002.

**Female.** Body (Fig. 3A) small, 676  $\mu$ m long. Cephalothorax nearly rectangular, longer than wide (444  $\times$  274  $\mu$ m in dissected specimen), slightly broadened posteriorly, with well-defined antennary area. Metasomites much narrower than cephalothorax. Urosome (Fig. 3B-D) indistinctly segmented



and prominently produced ventrally (Fig. 3D) as in preceding species; fifth pedigerous somite short and fused to genital double-somite, delimited from latter by faint dorsolateral lines; genital double-somite round, ventrally with spinules; first abdominal somite indistinctly delimited dorsally ( $16 \times 49 \mu\text{m}$ ) from but fused ventrally with genital double-somite; second abdominal somite  $13 \times 43 \mu\text{m}$ ; Anal somite  $19 \times 39 \mu\text{m}$ ; three abdominal somites with spinules along posteroventral border. Caudal ramus rectangular,  $33 \times 13 \mu\text{m}$  (ratio 2.54 : 1), with 4 terminal, naked caudal setae. Egg sac usually longer than body,  $603 \times 153 \mu\text{m}$  in dissected specimen.

Antennule (Fig. 3E) 6-segmented,  $101 \mu\text{m}$  long; armature formula 1, 11, 5, 4+1 aesthetasc, 2+1 aesthetasc, and 7; all setae naked; aesthetascs on fourth and fifth segments distally expanded. Antenna (Fig. 3F) 4-segmented. First segment  $62 \mu\text{m}$  long, longer than wide, with 1 distal seta. Second segment  $80 \times 38 \mu\text{m}$ , with outer proximal expansion ( $55 \mu\text{m}$  wide in this region) and 1 small, strongly recurved seta on inner margin. Third segment slender  $80 \mu\text{m}$  long, curved and  $14 \mu\text{m}$  wide in mid-length. Terminal claw  $50 \mu\text{m}$  long, with proximal seta.

Labrum (Fig. 4A) with linear posterior margin. Mandible (Fig. 4B) bearing posterior and distal blades. Maxillule (Fig. 4C) lobate bearing distally 2 setae and 1 process. Maxilla (Fig. 4D) 2-segmented; first segment unarmed; second segment divided by faint delimitation into proximal and distal parts, with 1 seta on proximal part and spinules on distal part.

Legs 1–3 with 3-segmented exopod and endopod (Fig. 4E, F). Leg 4 (Fig. 4G) with 2-segmented exopod and 3-segmented endopod. Endopodal segments of legs 1–4 with spinules on outer margin. Armature formula of legs 1–4 as follows:

Leg 1:	coxa 0-0;	basis 1-0;	exp. I-0; I-1; II, 5;	enp. 0-1; 0-1; II, 4.
Legs 2 & 3:	coxa 0-0;	basis 1-0;	exp. I-0; 0-1; 6;	enp. 0-1; 0-1; I, 4.
Leg 4:	coxa 0-0;	basis 1-0;	exp. I-0; 5;	enp. 0-1; 0-2; I, 3.

Leg 5 represented by a seta on anterolateral part of urosome (Fig. 3D).

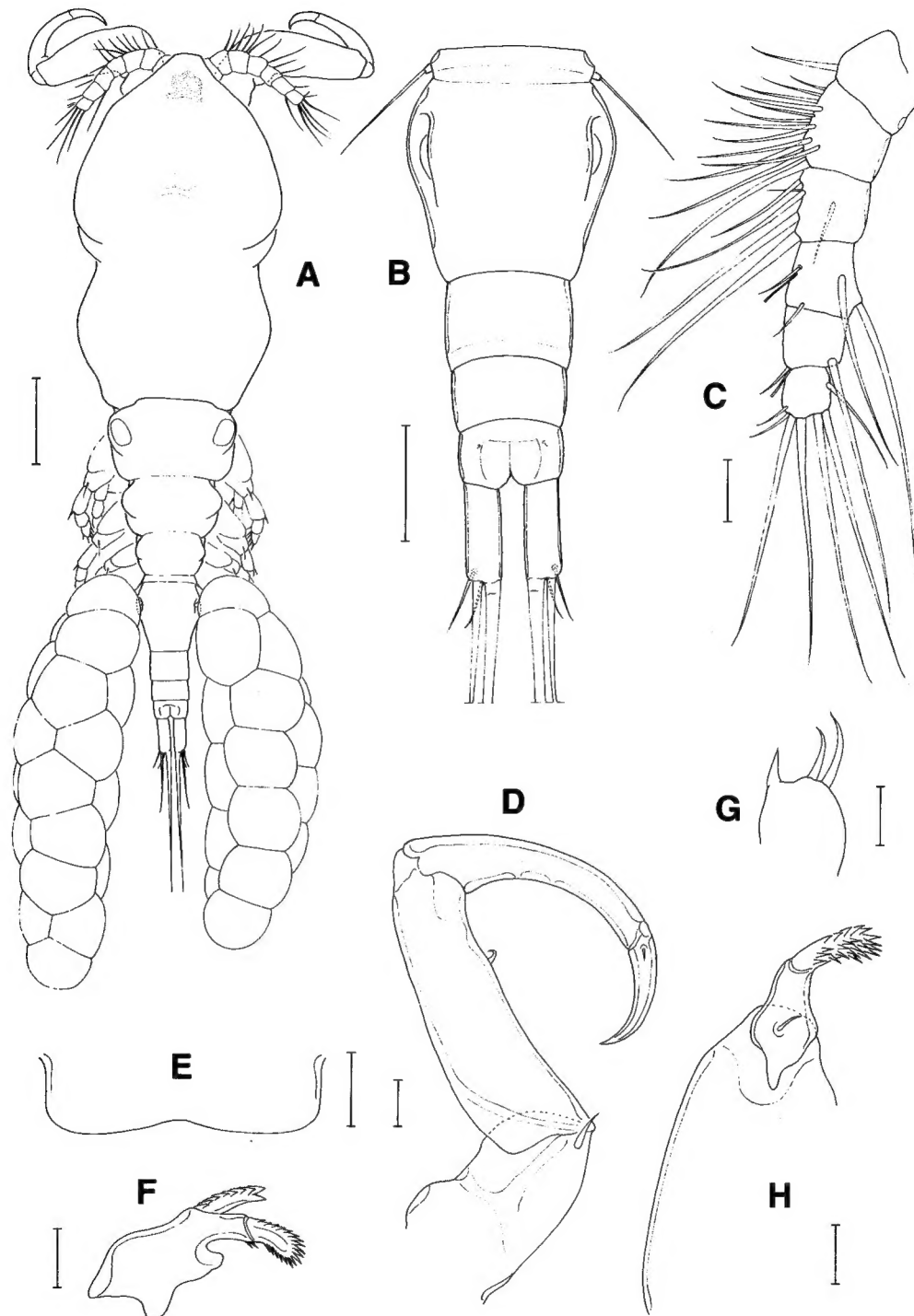
**Male.** Unknown.

**Etymology.** The specific name *ventriosus* is a Latin, meaning “potbellied”. It alludes the ventrally protuberant abdomen of the new species.

**Remarks.** *Ergasilus ventriosus* n. sp. is very similar to the preceding species *Ergasilus coniformis* n. sp. Both species have the characteristic abdomen which is protuberant ventrally, bearing indistinct or obsolete abdominal segmentations and a rudimentary leg 5 which is represented by a single seta. The presence of only a single inner seta on the second endopodal segment of legs 2 and 3 is also a remarkable resemblance. However, the new species differs from *E. coniformis* in the body shape (the cephalothorax of the new species is expanded and clearly defined from the rest of body), the more slender antenna, and in the absence of outer spine on the terminal exopodal segment of legs 2–4.

#### ***Ergasilus briani* Markewitsch, 1933 장구머리낫벌레 (신칭) (Figs. 5 and 6)**

**Material examined.** 2 ♀♀ removed from gills of *Squalidus chankaensis tsuchigae* from Jinyang Lake in Sacheon, Kyeongnam ( $35^{\circ}10'N$ ,  $128^{\circ}00'E$ ), 5 August 2002; 121 ♀♀ from gills of *Hemiculter eigenmanni* from Simgok Reservoir in Seo-myeon, Kyeongju ( $35^{\circ}54'N$ ,  $129^{\circ}04'E$ ) 4 August 2002; 1 ♀ from gill of *Odontovutis interrupta*, same locality and date; 1 ♀ from gill of



**Fig. 5.** *Ergasilus briani* Markewitsch, female. A, habitus, dorsal; B, urosome, dorsal; C, antennule; D, antenna; E, labrum; F, mandible; G, maxillule; H, maxilla. Scales: A, 0.1 mm; B, 0.05 mm; C-E, 0.02 mm; F-H, 0.01 mm.

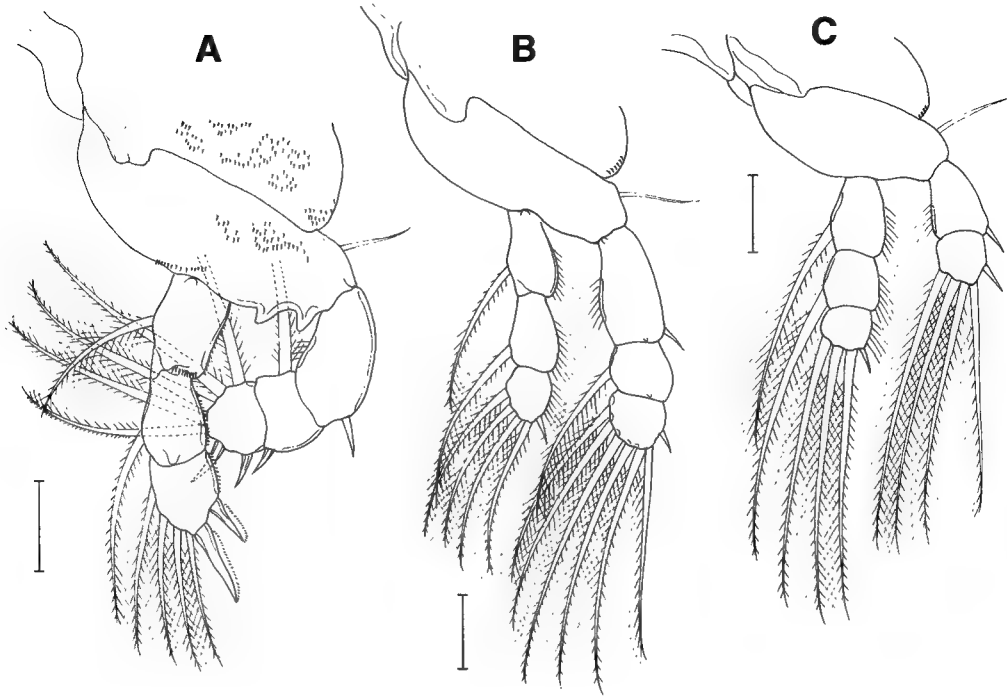


Fig. 6. *Ergasilus briani* Markewitsch, female. A, leg 1; B, leg 2; C, leg 4. Scales: 0.02 mm for all.

*Carassius auratus* from Namsa Reservoir in Hyeongok-myeon, Kyeongju (35° 54'N, 129° 09'E), 4 August 2002; 1 ♀ from gill of *Pseudorasbora parva* from Yeongin Reservoir in Inju-myeon, Asan, Choongnam (36° 52'N, 126° 57'E), 30 July 2002.

**Female.** Body (Fig. 5A) narrowed posteriorly, 824  $\mu$ m long. Cephalothorax longer than wide, 412  $\times$  244  $\mu$ m, strongly tapering anteriorly, with truncate apex, and distinct lateral constriction delimiting cephalosome and first pedigerous somite. Greatest width of body measured across cephalosome but occasionally across first pedigerous somite (in fully grown adults). Antennary area not delimited. Urosome (Fig. 5B) 5-segmented. Fifth pedigerous somite short and weakly demarcated from genital double-somite. Genital double-somite 80  $\times$  83  $\mu$ m, with round lateral margins. Three abdominal somites 35  $\times$  51, 25  $\times$  46, and 25  $\times$  42  $\mu$ m, respectively. No spinule found on surface of urosomal somites. Caudal ramus 40  $\times$  14  $\mu$ m (ratio 2.86 : 1), with 4 naked caudal setae.

Antennule (Fig. 5C) 6-segmented, 135  $\mu$ m long; armature formula 1, 13, 6, 4+1 aesthetasc, 2+1 aesthetasc, and 7. Aesthetascs on fourth and fifth segments very small, hardly distinguishable from nearby setae. Antenna (Fig. 5D) slender, without expanded area on basal segments; first segment longer than wide; second segment 125  $\mu$ m long, with small seta at distal 27% of inner margin; third segment 100  $\mu$ m long, narrowed distally; terminal claw 52  $\mu$ m long, distinctly curved evenly.

Labrum (Fig. 5E) with weakly concave posterior margin. Mandible (Fig. 5F) with posterior and

distal blades. Maxillule (Fig. 5G) distally armed with 2 setae and 1 process. Maxilla (Fig. 5H) as in preceding species.

Legs 1-3 with 3-segmented exopod and endopod (Fig. 6A, B). Leg 4 (Fig. 6) with 2-segmented exopod and 3-segmented endopod. Leg 1 characteristically with 1 pair of processes on posterior margin of basis between rami; exopod directed inward, usually perpendicular to endopod, Armature formula of legs 1-4 as follows:

Leg 1:	coxa 0-0;	basis 1-0;	exp. I-0; I-1; II, 5;	enp. 0-1; 0-1; II, 4.
Legs 2 & 3:	coxa 0-0;	basis 1-0;	exp. I-0; 0-1; I, 6;	enp. 0-1; 0-1; I, 4.
Leg 4:	coxa 0-0;	basis 1-0;	exp. I-0; I, 4;	enp. 0-1; 0-1; I, 3.

Leg 5 represented by small, papilla-like tapering segment ( $8 \times 7 \mu\text{m}$ ) tipped by 1 long seta (Fig. 5B).

**Male.** Undiscovered.

**Remarks.** The combination of the diagnostic features of this Eurasian species may be the possession of the slender body with the long, laterally constricted cephalothorax, the 6-segmented antennule bearing a single seta on the first segment, a pair of processes on the posterior margin of basis, only a single seta on the second endopodal segment of legs 2-4, and a single terminal seta tipped on the papilla-like leg 5.

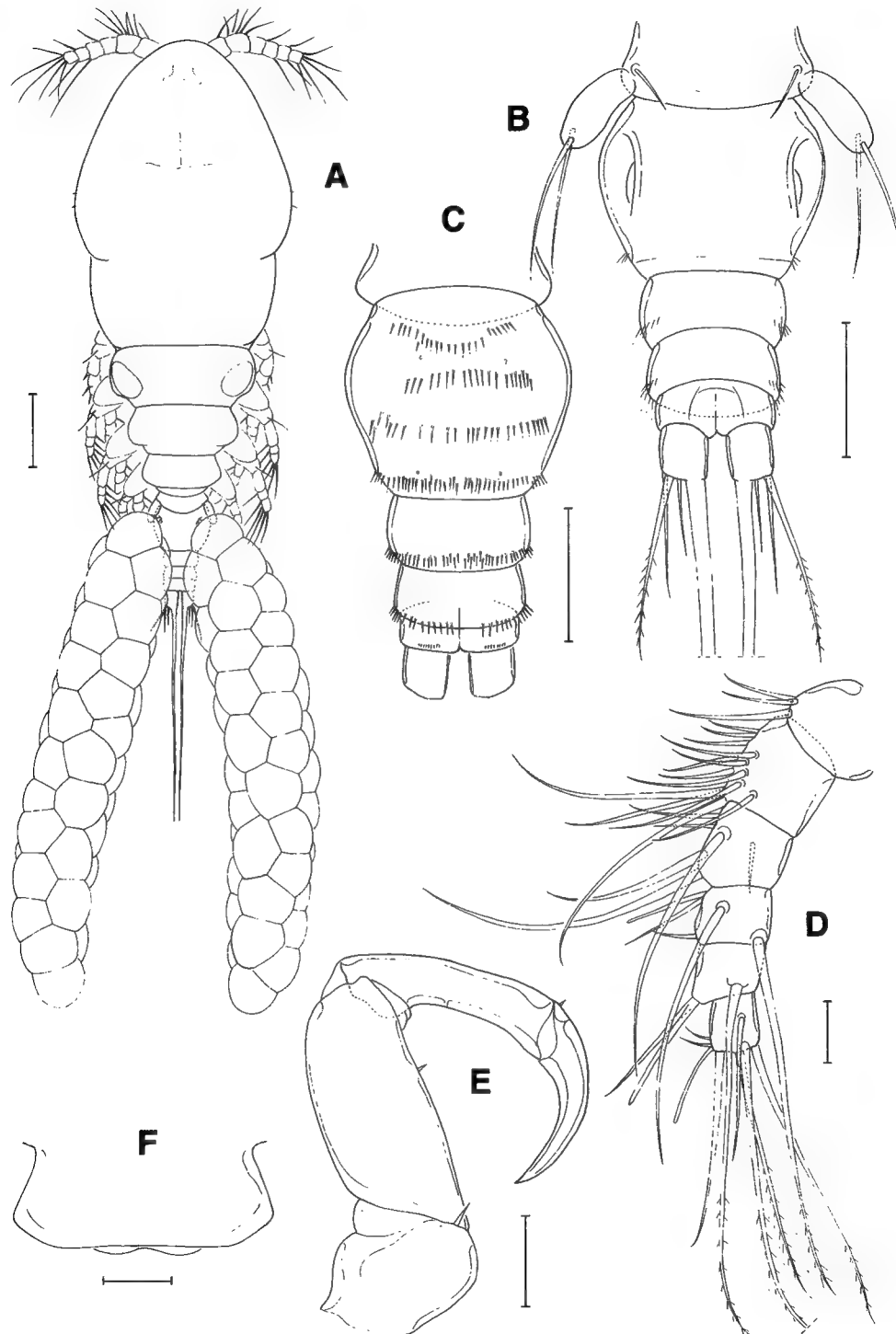
#### ***Ergasilus peregrinus* Heller, 1865** 쏘가리낫벌레 (신칭) (Figs. 7 and 8)

**Material examined.** 16 ♀♀ removed from gills of *Siniperca scherzeri* from Imha Lake in Andong, Kyeongbook ( $36^{\circ}31'N$ ,  $128^{\circ}53'E$ ), 4 August 2002.

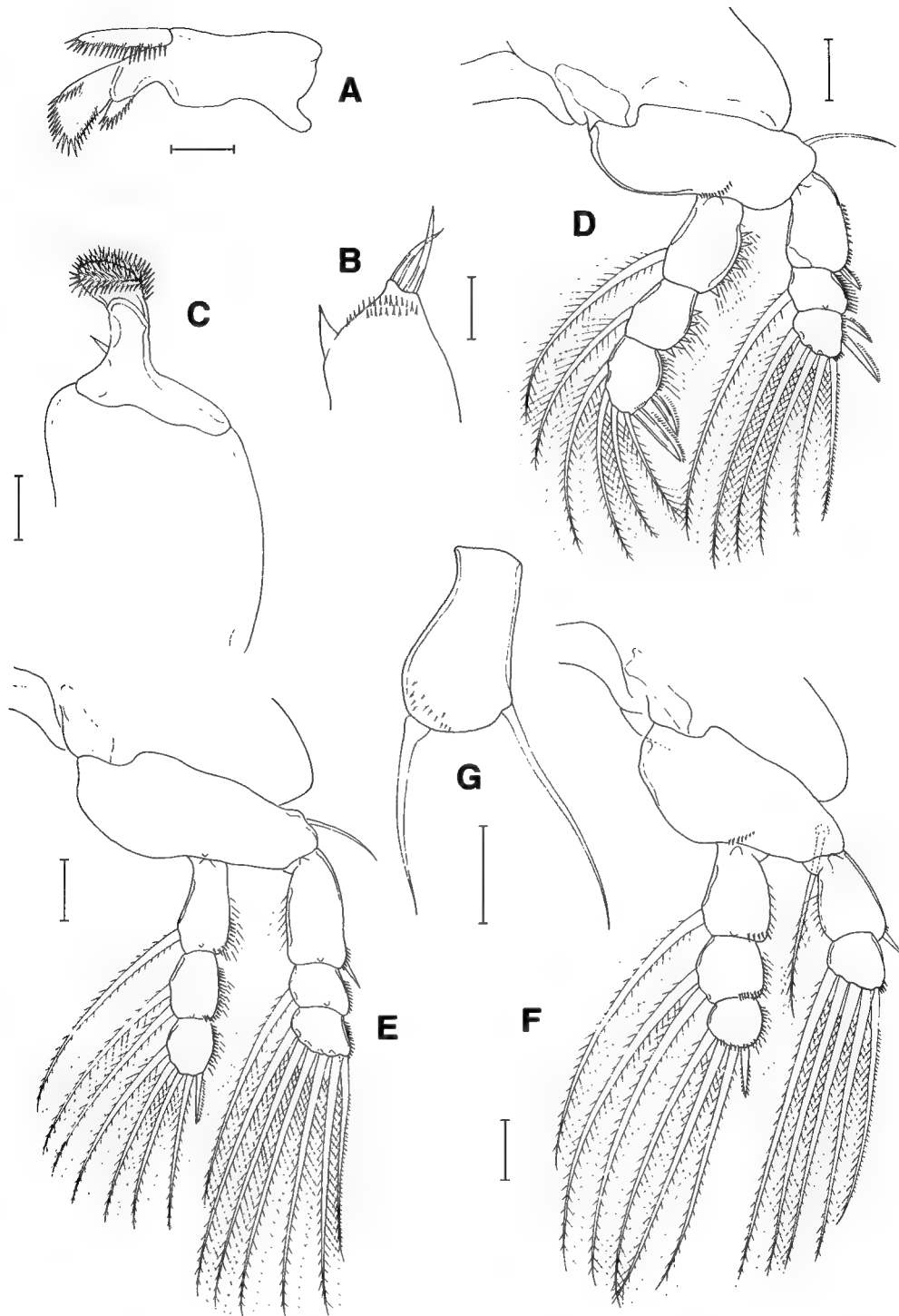
**Female.** Body (Fig. 7A) narrow,  $790 \mu\text{m}$  long. Cephalothorax distinctly longer than wide,  $420 \times 298 \mu\text{m}$ ; cephalosome and first pedigerous somite delimited by lateral constriction and incomplete dorsal line. Metasomites gradually narrowed posteriorly. Second pedigerous somite with rudimentary epimera. Urosome (Fig. 7B, C) 5-segmented. Fifth pedigerous somite  $71 \mu\text{m}$  wide. Genital double-somite  $68 \times 83 \mu\text{m}$ , with roundly convex lateral margins and about 4 transverse rows of spinules on ventral surface. Three abdominal somites  $27 \times 54$ ,  $20 \times 49$ , and  $21 \times 44 \mu\text{m}$ , respectively. Genital double-somite and first two abdominal somites ornamented with sensilla-like setules at posterolateral borders. First and second abdominal somites with row of spinules along posteroventral border. Caudal ramus  $20 \times 17 \mu\text{m}$  (ratio 1.18 : 1), with 4 caudal setae; largest median terminal seta fused with caudal ramus; outer second longest seta plumous in distal half. Egg sac usually long and narrow,  $708 \times 133 \mu\text{m}$  in dissected specimen.

Antennule (Fig. 7D) 6-segmented,  $130 \mu\text{m}$  long; armature formula 3, 13, 6, 4+1 aesthetasc, 2+1 aesthetasc, and 7+1 aesthetasc; aesthetascs thin. Antenna (Fig. 7E) 4-segmented, without proximal expansion; first segment wider than long, with small distal seta; second segment about twice as long as wide, with 1 minute seta on distal third of inner margin; third segment slightly shorter than second segment; terminal claw about 70% as long as third segment, with minute proximal seta on outer margin.

Labum (Fig. 7F) broadened posteriorly, with linear posterior margin and weak W-shaped expansion extending beyond posterior margin. Mandible (Fig. 8A) with 3 spinulated blades; anterior blade small. Maxillule (Fig. 8B) with 2 distal setae, 1 subdistal process and distal spinules. Maxilla



**Fig. 7.** *Ergasilus peregrinus* Heller, female. A, habitus, dorsal; B, urosome, dorsal; C, same, ventral; D, antennule; E, antenna; F, labrum. Scales: A, 0.1 mm; B, C, E, 0.05 mm; D, F, 0.02 mm.



**Fig. 8.** *Ergasilus peregrinus* Heller, female. A, mandible; B, maxillule; C, maxilla; D, leg 1; E, leg 2; F, leg 4; G, free segment of leg 5. Scales: A-C, 0.01 mm; D-G, 0.02 mm.

(Fig. 8C) 2-segmented; first segment unarmed; second segment 1 small proximal seta and expanded distal part armed with numerous spinules.

Legs 1-3 with 3-segmented rami (Fig. 8D, E). Leg 4 (Fig. 8F) with 2-segmented exopod and 3-segmented endopod. First and second exopodal segments of leg 1 with dentiform spinules on outer margin. Armature formula of legs 1-4 as follows:

Leg 1:	coxa 0-0;	basis 1-0;	exp. I-0; I-1; II, 5;	enp. 0-1; 0-1; II, 4.
Legs 2 & 3:	coxa 0-0;	basis 1-0;	exp. I-0; 0-1; 6;	enp. 0-1; 0-2; I, 4.
Leg 4:	coxa 0-0;	basis 1-0;	exp. I-0; 5;	enp. 0-1; 0-2; I, 3.

Leg 5 represented by 1 seta on dorsolateral seta on fifth pedigerous somite and free segment. Free segment  $38 \times 21 \mu\text{m}$  (ratio 1.81 : 1), distally widened, and armed with 2 widely separated setae (50 and  $41 \mu\text{m}$ , respectively) and distal spinules. Leg 6 not seen.

**Male.** Undiscovered.

**Remarks.** Up to date, this species has been reported from China and Far Eastern Siberia from the fishes of the genera, *Siniperca*, *Elopichthys*, *Leuciscus* and *Hemibarbus* (Yin, 1956; Dogiel and Akhmerov, 1952).

Genus *Neoergasilus* Yin, 1956 신낫벌레속

***Neoergasilus inflatus* Yin, 1956 풍선신낫벌레 (신칭) (Figs. 9 and 10)**

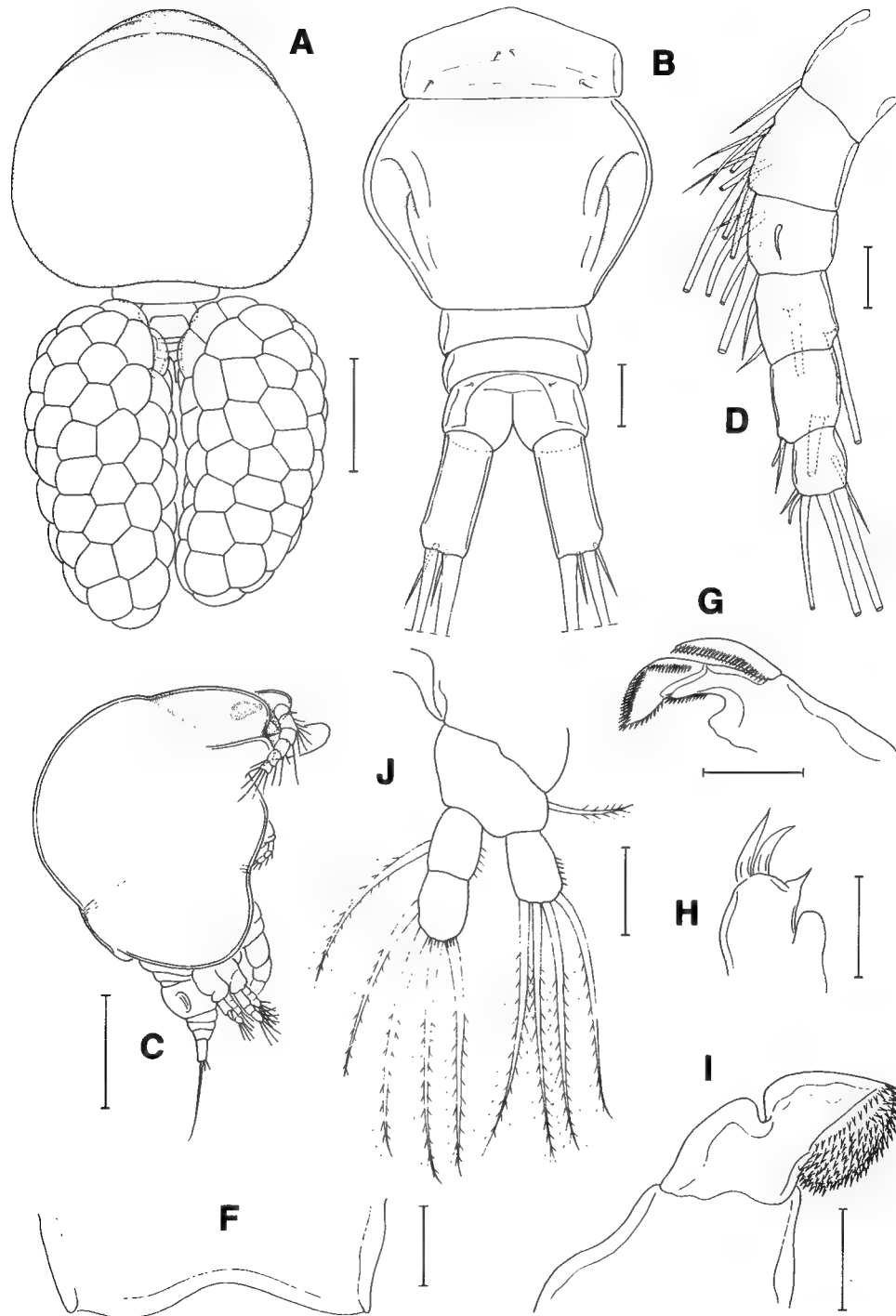
**Material examined.** 1 ♀ removed from branchial cavity of *Zacco platypus* (Temminck and Schlegel) from a stream in Okcheon-myeon, Yangpyeong-gun, Gyeonggi-do ( $37^{\circ}32'N$ ,  $127^{\circ}28'E$ ), 1 August 2002; 11 ♀♀ from gills of *Zacco platypus* from Daeryong-cheon in Sinpoong-myeon, Kongju ( $36^{\circ}30'N$ ,  $126^{\circ}57'E$ ), 30 July 2002.

**Female.** Body (Fig. 9A, C)  $620 \mu\text{m}$  long. Cephalothorax nearly spherical, greatly expanded,  $458 \times 496 \mu\text{m}$ , and  $391 \mu\text{m}$  deep. Rostral area hardly visible from dorsal view of body. Urosome (Fig. 9B) 5-segmented. Fifth pedigerous somite  $74 \mu\text{m}$  wide, with strait lateral margins. Genital double-somite  $71 \times 96 \mu\text{m}$ , with roundly convex lateral margins. Three abdominal somites short,  $14 \times 50$ ,  $13 \times 48$ , and  $21 \times 48 \mu\text{m}$ , respectively. Genital double- and abdominal somites with row of spinules along posteroventral border. Caudal ramus  $40 \times 17 \mu\text{m}$  (ratio 2.35 : 1), with 4 naked caudal setae and spinules at disteroventral regions near bases of 2 smaller caudal setae. Egg sac usually nearly ovoid, weakly tapering, and  $529 \times 250 \mu\text{m}$  in dissected specimen.

Antennule (Fig. 9D) 6-segmented and  $162 \mu\text{m}$  long; armature formula 1, 8, 4, 4, 2+1 aesthetasc, and 7+1 aesthetasc. Antenna not observed (broken in all specimens collected).

Labrum (Fig. 9F) with concave posterior margin. Mandible (Fig. 9G) with 2 spinulated blades. Maxillule (Fig. 9H) with 2 terminal setae and 1 subterminal process. Maxilla (Fig. 9I) 2-segmented; first segment unarmed; second segment armed with numerous spinules (or denticles) on distal expanded portion.

Legs 1-3 with 3-segmented rami (Fig. 10A, B). Leg 4 (Fig. 9J) with 1-segmented exopod and 2-segmented endopod. Outer seta on basis of legs 1-4 plumous. Outer spine of second exopodal segment of leg 1 enlarged, slightly narrower but longer than third exopodal segment; other outer spines on exopod with subdistal flagellum. Outer spine of third exopodal segment of leg 3 tiny. Armature formula of legs 1-4 as follows:



**Fig. 9.** *Neoergasilus inflatus* Yin, female. A, habitus, dorsal; B, urosome, dorsal; C, habitus, lateral; D, antennule; E, labrum; F, mandible; G, maxillule; H, maxilla; I, leg 4. Scales: A, C, 0.2 mm; B, D, F-J, 0.02 mm.



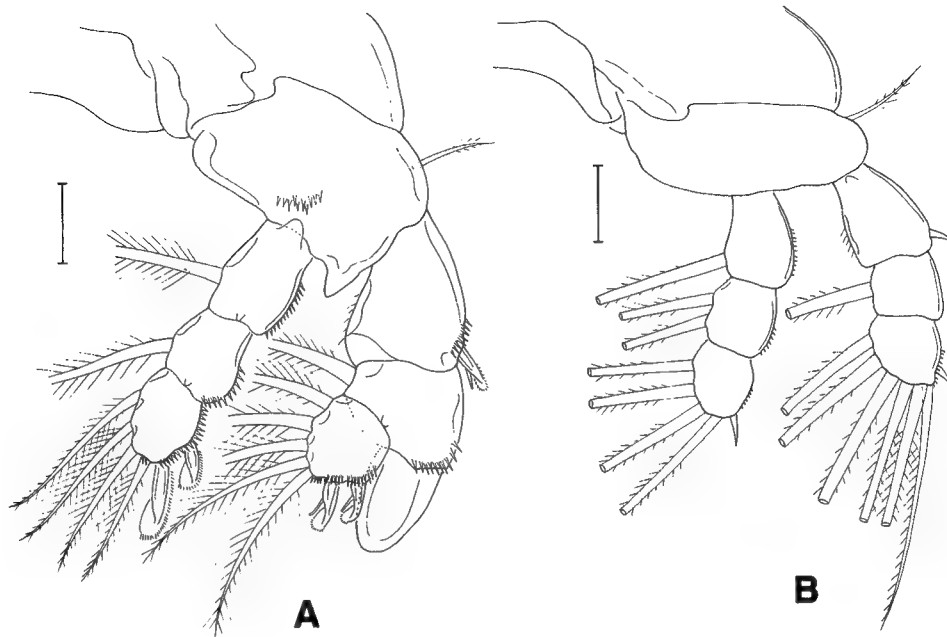


Fig. 10. *Neoergasilus inflatus* Yin, female. A, leg 1; B, leg 2. Scales: 0.02 mm for all.

Leg 1:	coxa 0-0;	basis 1-0;	exp. I-0; I-1; II, 5;	enp. 0-1; 0-1; II, 4.
Legs 2 & 3:	coxa 0-0;	basis 1-0;	exp. I-0; 0-1; I, 6;	enp. 0-1; 0-2; I, 4.
Leg 4:	coxa 0-0;	basis 1-0;	exp. 4;	enp. 0-1; 4.

Legs 5 and 6 absent.

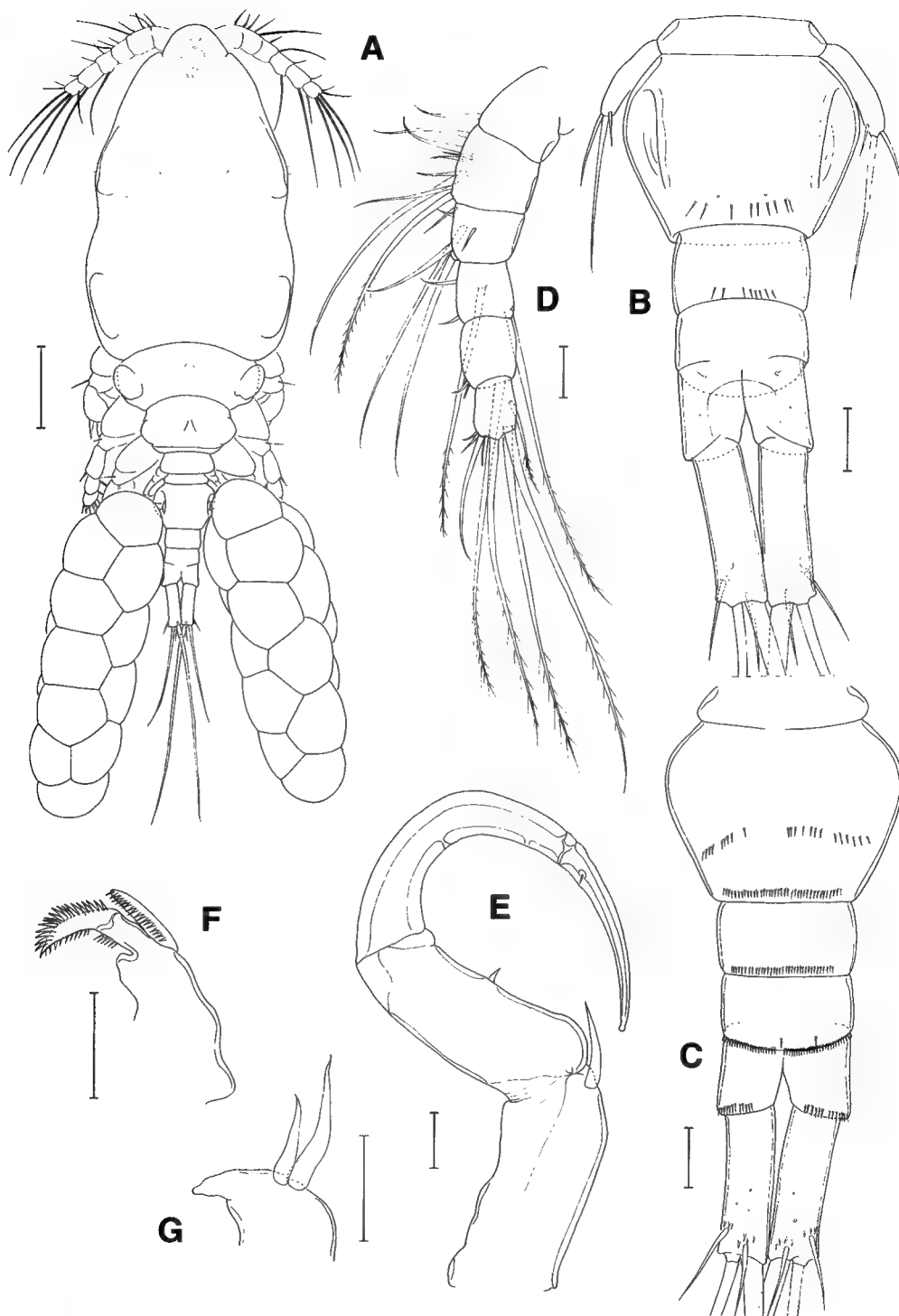
**Male.** Undiscovered.

**Remarks.** *Neoergasilus inflatus* may be clearly defined from its congeners by a combination of the following characteristics: the tumid cephalothorax, the segmentation of leg 4 bearing a single-segmented exopod and 2-segmented endopod, and the absence of leg 5.

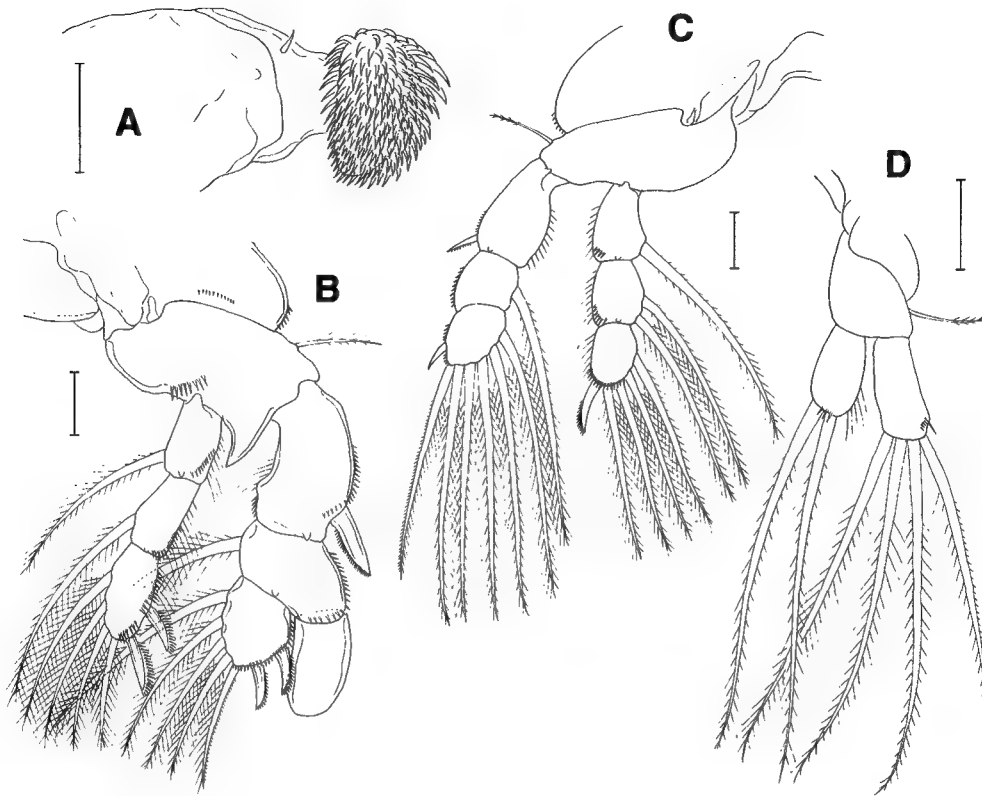
According to the original record, the antenna of this species is also characteristic, with the strongly curved distal part and an acute, recurved process at the terminal part of the third segment. Hence, we failed to obtain any intact specimen of this species bearing an undamaged antenna.

***Neoergasilus japonicus* (Harada, 1930) 일본신낫벌레 (신칭) (Figs. 11 and 12)**

**Material examined.** 1) from *Carassius auratus* (L.): 1 ♀ (from gill) from a pond in Byeongsan-dong, Kangnung (37° 46'N, 128° 57'E), 4 July 2002; 2 ♀ ♀ (from branchial cavity) from the same locality, 27 July 2002; 2) from gills of *Siniperca scherzeri* (Steindachner): 4 ♀ ♀ from Imha Lake in Andong, Kyeongbook (36° 31'N, 128° 53'E), 4 August 2002; 3) from *Zacco platypus*: 55 ♀ ♀ (from gills and skin) from Jookheon Reservoir in Kangnung (37° 47'N, 128° 52'E), 24 July 2002; 14 ♀ ♀ (from fins) from Kobok Reservoir in Seo-myeon, Yeonki-gun, Choongnam, (36° 36'N, 127° 14'E), 31 July 2002; 4) from *Pseudorasbora parva*: 1 ♀ (from gill) from Jookheon Reservoir



**Fig. 11.** *Neoergasilus japonicus* (Harada), female. A, habitus; B, urosome, dorsal; C, same, ventral; D antennule; E, antenna; F, mandible; G, maxillule. Scales: A, 0.1 mm; B-G, 0.02 mm.



**Fig. 12.** *Neoergasilus japonicus* (Harada), female. A, maxilla; B, leg 1; C, leg 2; D, leg 4. Scales: 0.02 mm for all.

in Kangnung (37°47'N, 128°52'E), 24 July 2002; 5) from *Lepomis macrochirus*: 152 ♀♀ (from skin and branchial cavity) from Kobok Reservoir in Seo-myeon, Yeonki-gun, Choongnam (36°36'N, 127°14'E), 31 July 2002; 18 ♀♀ (from fins) from Kasan Reservoir in Boobok-myeon, Milyang (35°32'N, 128°42'E), 5 August 2002; numerous ♀♀ (from gills and fins) from Songhyeon Reservoir in Bonghwang-myeon, Naju (34°58'N, 126°49'E), 8 August 2002; 6) from *Hemiculter eigenmanni*: 1 ♀ (from fin) from Simkog Reservoir in Seo-myeon, Kyeongju (35°54'N, 129°04'E), 4 August 2002; 7) from *Cyprius carpio*: 6 ♀♀ (from fins) from Jinyang Lake in Sacheon, Kyeongnam (35°10'N, 128°00'E), 5 August 2002; 8) from *Micropterus salmoides*: 29 ♀♀ (from fins) from Daeyool Reservoir in Kumgoo-myeon, Kimje (35°47'N, 127°02'E), 8 August 2002; 9) from *Squalidus japonicus coreanus*: 12 ♀♀ (from fins) from Sinhung Reservoir in Hyeondong-myeon, Cheongsong, Kyeongbook (36°16'N, 129°03'E), 3 August 2002; 10) from *Pungtungia herzi*: 2 ♀♀ (from fins) from Sinhung Reservoir in Hyeondong-myeon, Cheongsong, Kyeongbook (36°16'N, 129°03'E), 3 August 2002.

**Female.** Body (Fig. 11A) moderately narrow, 750 µm long. Cephalothorax slightly broadened distally, 260 µm wide, and 1.62 time as long as wide. Rostral area weakly delimited from rest of cephalothorax. First pedigerous somite weakly delimited from cephalosome by weak lateral

constriction and faint dorsal line, with rudimentary epimera on dorsolateral sides, Second to fourth pedigerous somites distinctly narrower posteriorly. Second pedigerous somite with epimera. Urosome (Fig. 11B, C) 5-segmented. Fifth pedigerous somite short,  $13 \times 67 \mu\text{m}$ , without dorsolateral setae. Genital double-somite roundly convex laterally,  $63 \times 79 \mu\text{m}$ , with row of spinules on ventral surface, and along posterodorsal and poteroventral borders.. Three abdominal somites with row of minute spinules along poteroventral border,  $25 \times 46$ ,  $18 \times 44$ , and  $29 \times 43 \mu\text{m}$ , respectively. Anal somite with deep posteromedian incision. Caudal ramus  $54 \times 16 \mu\text{m}$  (ratio 3.38:1), slightly widened distally, with 4 naked setae and several ventral spinules; smaller 2 caudal setae inserted ventrally.

Antennule (Fig. 11D) 6-segmented and  $150 \mu\text{m}$  long; armature formula 1, 8, 6, 4, 2+1 aesthetasc, and 7+1 aesthetasc; aesthetascs very small. Antenna (Fig. 11E) slender and 4-segmented; combined distal 3 segments making circle; first segment  $75 \mu\text{m}$  long, about twice as long as wide, with prominent inner distal seta; second segment same as first in length, slightly narrowed distally, with 1 seta at slightly beyond mid-length of inner margin; third segment longest,  $92 \mu\text{m}$  long, strongly curved, narrowed distally, and unarmed; terminal claw weakly curved, slender,  $68 \mu\text{m}$  long, with 1 small proximal seta.

Labrum not examined. Mandible (Fig. 11F) with 2 spinulated blades. Maxillule (Fig. 11G) with 2 setae and 1 thick process. Maxilla (Fig. 12A) 2-segmented; first segment unarmed; second segment with 1 proximal seta and numerous spinules on expanded distal part.

Legs 1-3 with 3-segmented exopod and endopod (Fig. 12B, C). Leg 4 (Fig. 12D) with 1-segmented exopod and endopod. Basis of leg 1 with large, pointed process between rami. Outer spine of second exopodal segment of leg 1 greatly enlarged, extending well over third segment. Outer spine on exopod of leg 4 very small, hair-like. Armature formula of legs 1-4 as follows:

Leg 1:	coxa 0-0;	basis 1-0;	exp. I-0; I-1; II, 5;	enp. 0-1; 0-1; II, 4.
Legs 2 & 3:	coxa 0-0;	basis 1-0;	exp. I-0; 0-1; I, 6;	enp. 0-1; 0-2; I, 4.
Leg 4:	coxa 0-0;	basis 1-0;	exp. I, 4;	enp. 2

Leg 5 consisted of free segment ( $33 \times 7 \mu\text{m}$ , ratio 4.71) bearing 3 terminal setae (55, 27, and  $10 \mu\text{m}$  long, respectively). Leg 6 not seen.

**Male.** Undiscovered.

**Remarks.** *Neoergasilus japonicus* may be the most prevalent copepod parasite of the Korean freshwater fishes, because as many as ten species of freshwater fishes turned out to be hosts of this copepod in this country. It is easily identifiable without dissection on the basis of the morphology of leg 4 bearing the single-segmented exopod and endopod. This species was unknown in Europe until 1960s, but has since been reported from several areas, including Britain (Fryer, 1982). As previous reports, we also found this copepod attached to fins as well as gills of hosts.

#### ***Neoergasilus longispinosus* Yin, 1956** 큰가시진뱃벌레

**Material examined.** 1) from *Carassius auratus*: 3♀♀ removed from branchial cavity of the host from a pond in Byeongsan-domg, Kangnung ( $37^{\circ}46'N$ ,  $128^{\circ}57'E$ ), 4 July 2002; 2♀♀ from branchial cavity of the host from Yeongin Reservoir in Inju-myeon, Asan, Choongnam ( $36^{\circ}52'N$ ,  $126^{\circ}57'E$ ), 30 July 2002; 1♀ from nasal cavity of the host from Daeyool Reservoir in Kumgoo-

myeon, Kimje, Jeonbook (35° 47'N, 127° 02'E), 8 August 2002.; 2) from *Hemiculter eigenmanni*: 1 ♀ from gill of the host from Daeyool Reservoir, Kumgoo-myeon, Kimje, Jeonbook (35° 47'N, 127° 02'E), 8 August 2002; 3) from *Culter brevicauda*: 8 ♀ ♀ from mouth cavity of the host from Sinpoong Reservoir in Jibo-myeon, Andong (36° 47'N, 128° 26'E), 3 August 2002; 4) from *Pseudorasbora parva*: 1 ♀ from branchial cavity of the host from Jookheon Reservoir, Kangnung (37° 47'N, 128° 52'E), 7 July 2002.

**Remarks.** In Korea, Kim (1998) recorded this species from the gills of *Carassius auratus*. In this study three more species of fishes are added as hosts of this copepod.

***Neogasilus bullatus* n. sp. 뽕보신낚벌레 (신칭) (Figs. 13 and 14)**

**Material examined.** 4 ♀ ♀ removed from gills of *Zacco platypus* (Temminck and Schlegel). Holotype (♀) and paratypes (2 ♀ ♀) will be deposited in the U. S. National Museum of Natural History, Smithsonian Institution, Washington D.C. Dissected paratype (1 ♀) is kept in the collection of the senior author.

**Other material examined.** 1 ♀ removed from gill of *Zacco platypus* from Daeryong-cheon, Sinpoong-ri, Kongju (36° 30'N, 126° 57'E), 30 July 2002; 2 ♀ ♀ from gills of *Zacco platypus* from Yookoo-cheon in Yookoo, Kongju, Choongnam (36° 38'N, 126° 59'E), 30 July 2002.

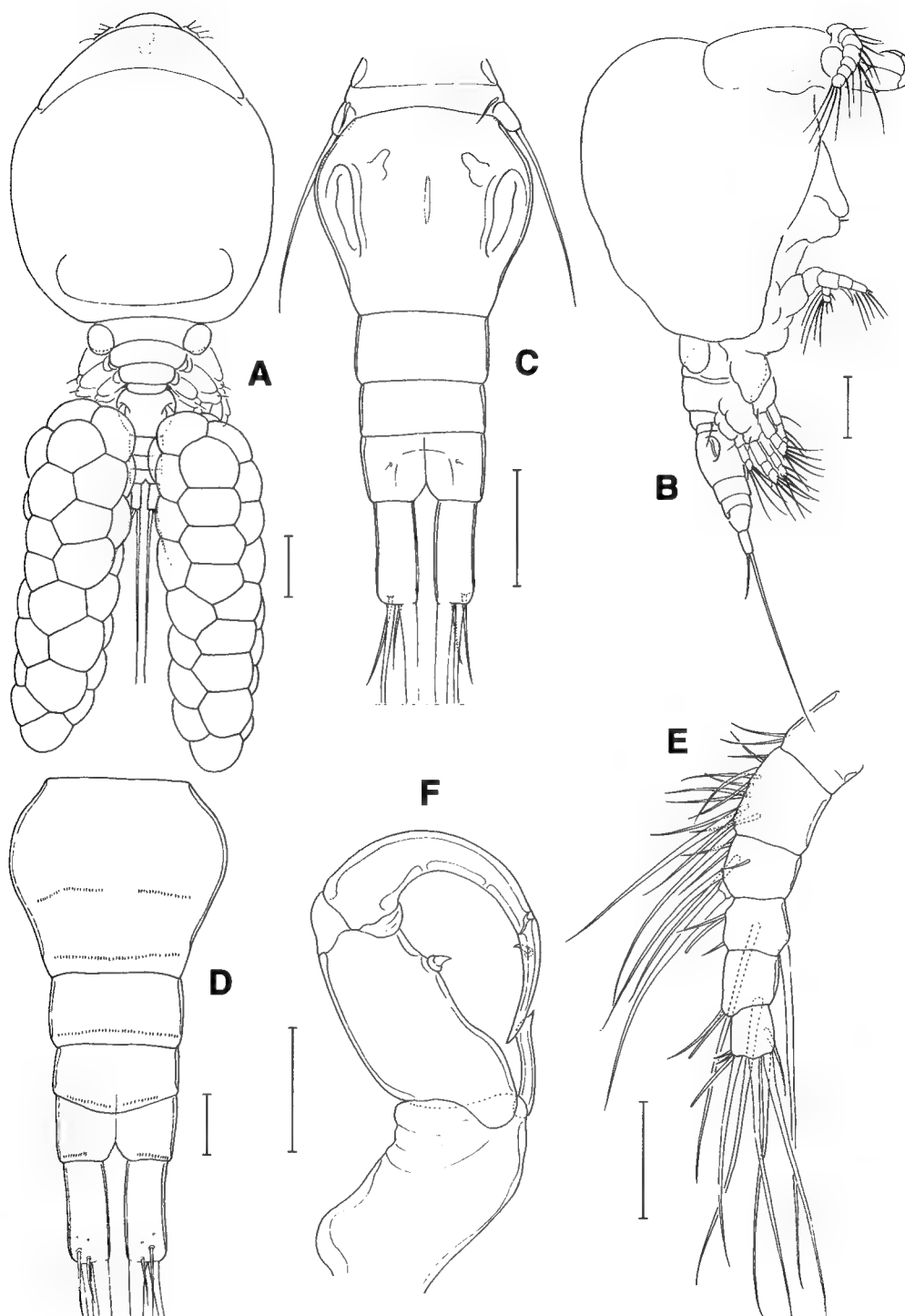
**Female.** Body (Fig. 13A) 875 µm long. Cephalothorax greatly expanded, 520 × 442 µm, 458 µm deep, with rudimentary tergite on posterodorsal part. Antennary area well defined in lateral view (Fig. 13B). Second pedigerous somite with rudimentary epimera on dorsolateral parts. Genital double-somite 85 × 94 µm, with roundly convex lateral margins. Three abdominal somites 30 × 57, 22 × 54, and 28 × 53 µm, respectively. Genital double- and abdominal somites ventrally with row of minute spinules as in Fig. 13D. Caudal ramus rectangular, 45 × 18 µm (ratio 2.50 : 1), armed with 4 caudal setae; largest median terminal seta fused with caudal ramus; smaller 2 caudal setae inserted ventrally to caudal ramus. Egg sac variable in size, 542 × 183 µm in dissected specimen.

Antennule (Fig. 13E) 6-segmented and 162 µm long, with armature formula: 2, 13, 6, 4 + 1 aesthetasc, 2 + 1 aesthetasc, and 7 + 1 aesthetasc. Antenna (Fig. 13F) 4-segmented; first segment approximately 1.7 times as long as wide, with 1 large, scalpel-like inner distal seta; second segment as long as first segment, with 1 papillate seta on distal third of inner margin; third segment strongly curved, tapering, as long as second segment, and unarmed; terminal clas less than half length of third segment with 1 proximal seta.

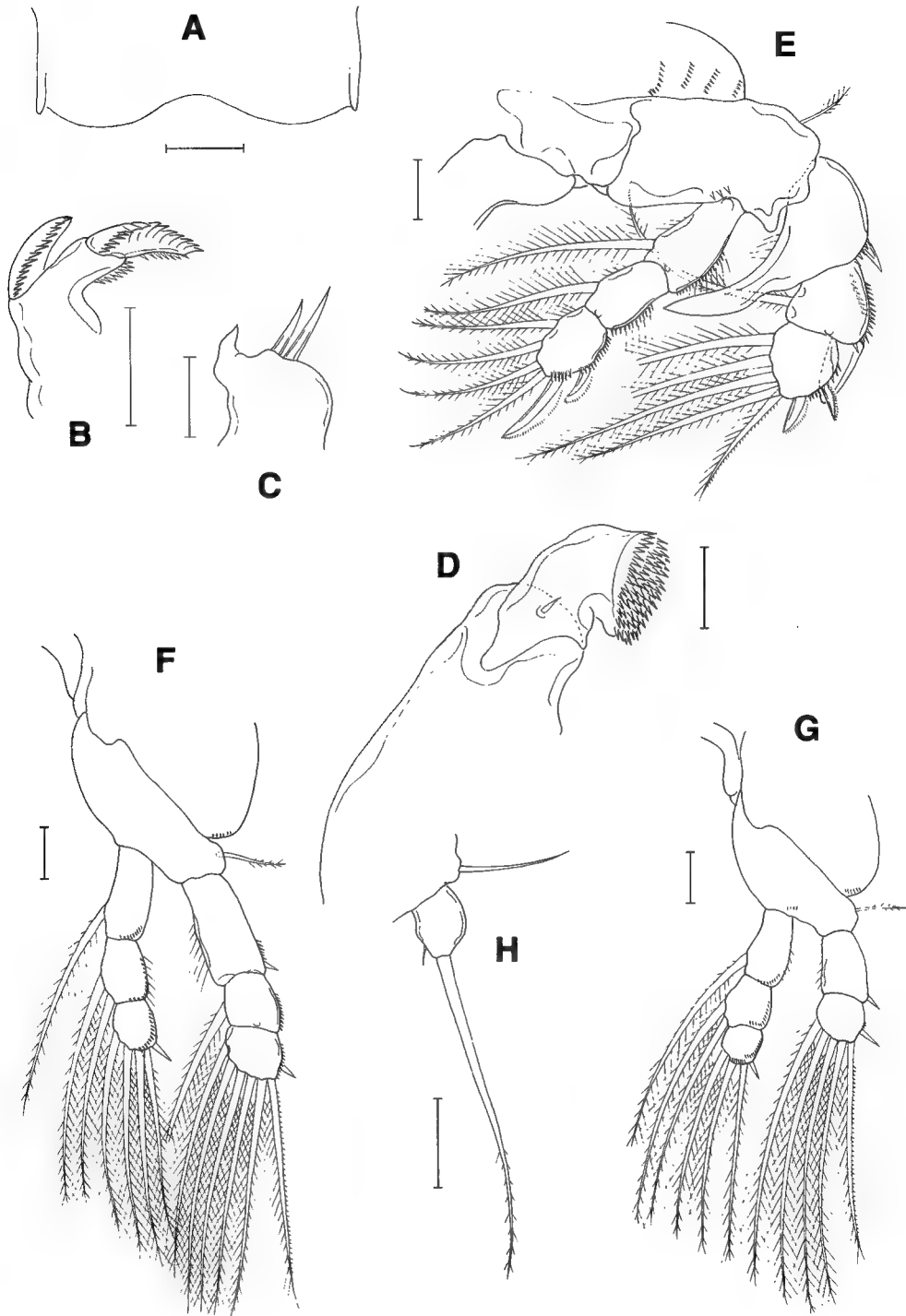
Labrum (Fig. 14A) with concave posterior margin. Mandible (Fig. 14B) with 2 blades. Maxillule (Fig. 14C) distally with 2 setae and 1 up-curved process. Maxilla (Fig. 14D) 2-segmented; first segment unarmed; second segment with 1 proximal seta and spinules (barbs) on expanded distal portion.

Legs 1-3 with 3-segmented rami (Fig. 14E, F). Leg 4 (Fig. 14G) with 2-segmented exopod and 3-segmented endopod. First exopodal segment of leg 1 characteristically with large inner distal process much longer than segment itself; outer spine of second exopodal segment of same leg enlarged, as long as third segment. First segments of rami in legs 2-3 elongate. Armature formula of legs 1-4 as follows:

Leg 1:	coxa 0-0;	basis 1-0;	exp. I-0; I-1; II, 5;	enp. 0-1; 0-1; II, 4.
Legs 2 & 3:	coxa 0-0;	basis 1-0;	exp. I-0; 0-1; I, 6;	enp. 0-1; 0-2; I, 4.



**Fig. 13.** *Neoergasilus bullatus* n. sp., female. A, habitus, dorsal; B, same, lateral; C, urosome, dorsal; D same, ventral; E, antennule; F, antenna. Scales: A, B. 0.1 mm; C-F. 0.05 mm.



**Fig. 14.** *Neoergasilus bullatus* n. sp., female. A, labrum; B, mandible; C, maxillule; D, maxilla; E, leg 1; F, leg 2; G, leg 4; H, leg 5. Scales: 0.02 mm for all.

Leg 4: coxa 0-0; basis 1-0; exp. 1-0; 1, 5; enp. 0-1; 0-2; 1, 3.

Leg 5 (Fig. 14H) represented by 1 dorsolateral seta of fifth pedigerous somite and free segment; free segment small,  $10 \times 12 \mu\text{m}$ , with 1 minute inner and 1 large, distally plumous terminal seta. Leg 6 not seen.

**Male.** Undiscovered.

**Etymology.** The specific name *bullatus*, a Latin meaning "inflated", alludes the inflated cephalothorax of the new species.

**Remarks.** Of the ergasilid copepods that we obtained from the fish *Zacco platypus*, two species are found to be similar in body form to each other. One is *Neoergasilus inflatus* and the other being *N. bullatus* n. sp. *Neoergasilus bullatus* is relatively less inflated than *N. inflatus* and carries elongate egg sacs. A comparison of the Korean specimens of these two species with Yin's (1956) original illustrations results in a suggestion that Fig. 1 of his Plate XI concerns with *N. bullatus*, rather than with *N. inflatus*. The less inflated cephalothorax and the elongate egg sacs shown in the figure are the traits of *N. bullatus*, and other figures are related to *N. inflatus*.

The diagnostic features of this species is the presence of the two setae on the first antennary segment, the enlarged inner process on the first exopodal segment of leg 1, and leg 4 bearing 2-segmented exopod and 3-segmented endopod. Of these, the enlarged inner process on the first exopodal segment of leg 1 is the unique feature not only among the copepods of *Neoergasilus* but among all known species of other genera in Ergasilidae.

***Neoergasilus angustus* n. sp. 홀쭉신 낫벌레 (신칭) (Figs. 15 and 16)**

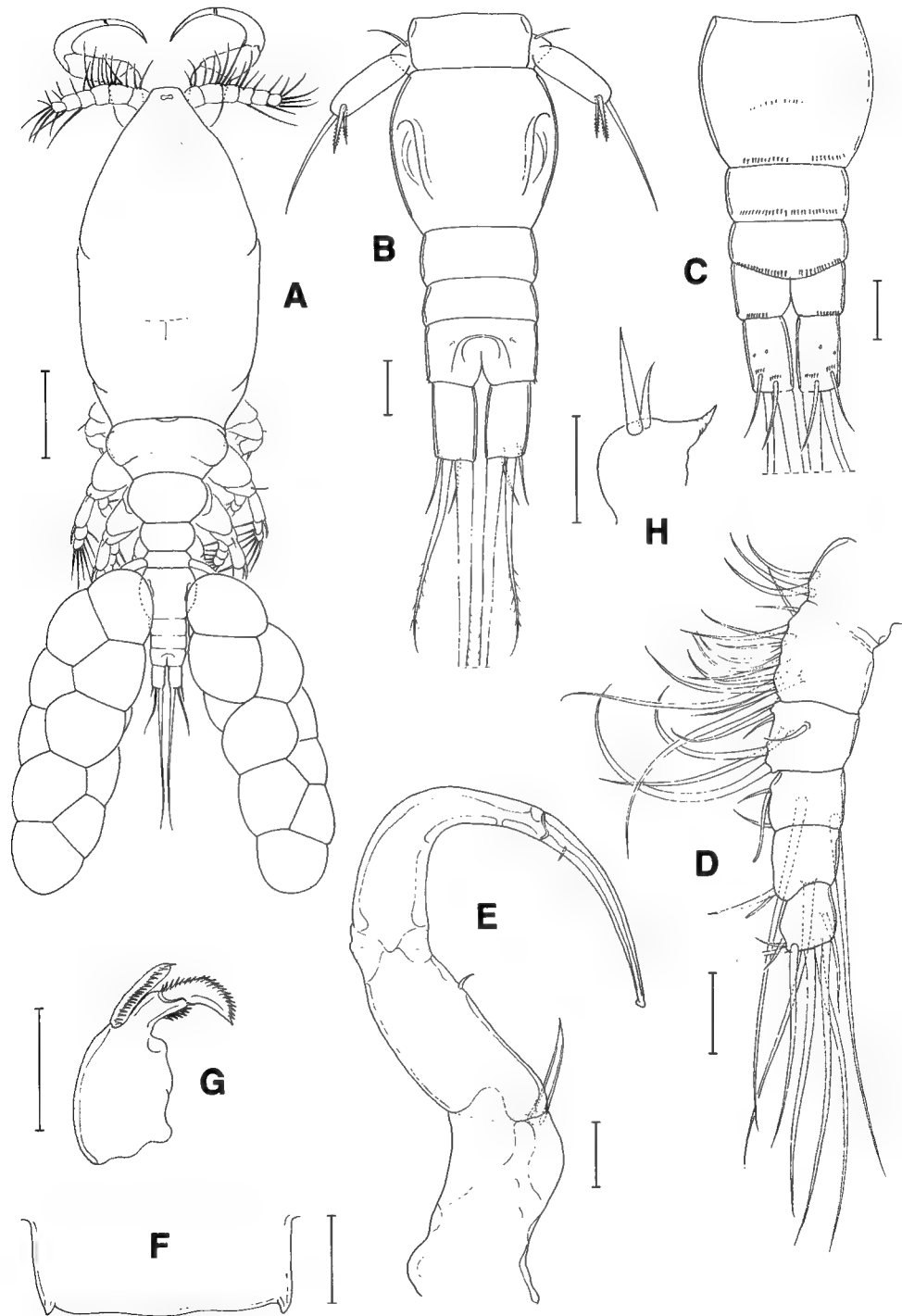
**Material examined.** 19 ♀♀ removed from branchial cavity of *Zacco platypus* (Temminck and Schlegel) from Jookheon Reservoir in Kangnung ( $37^{\circ}47'N$ ,  $128^{\circ}52'E$ ), 11 July 2002. Holotype (♀) and paratypes (15 ♀♀) will be deposited in the U. S. National Museum of Natural History, Smithsonian Institution, Washington D.C. Dissected paratype (1 ♀) and 2 intact specimens are kept in the collection of the senior author.

**Other material examined.** 30 ♀♀ removed from branchial cavity of *Pseudorasbora parva* from Jookheon Reservoir in Kangnung ( $37^{\circ}47'N$ ,  $128^{\circ}52'E$ ), 11 July 2002; 28 ♀♀ from branchial cavity of *Micropterus salmoides* from Daeyool Reservoir, Kumkoo-myeon, Kimje ( $35^{\circ}47'N$ ,  $127^{\circ}02'E$ ), 8 August 2002.

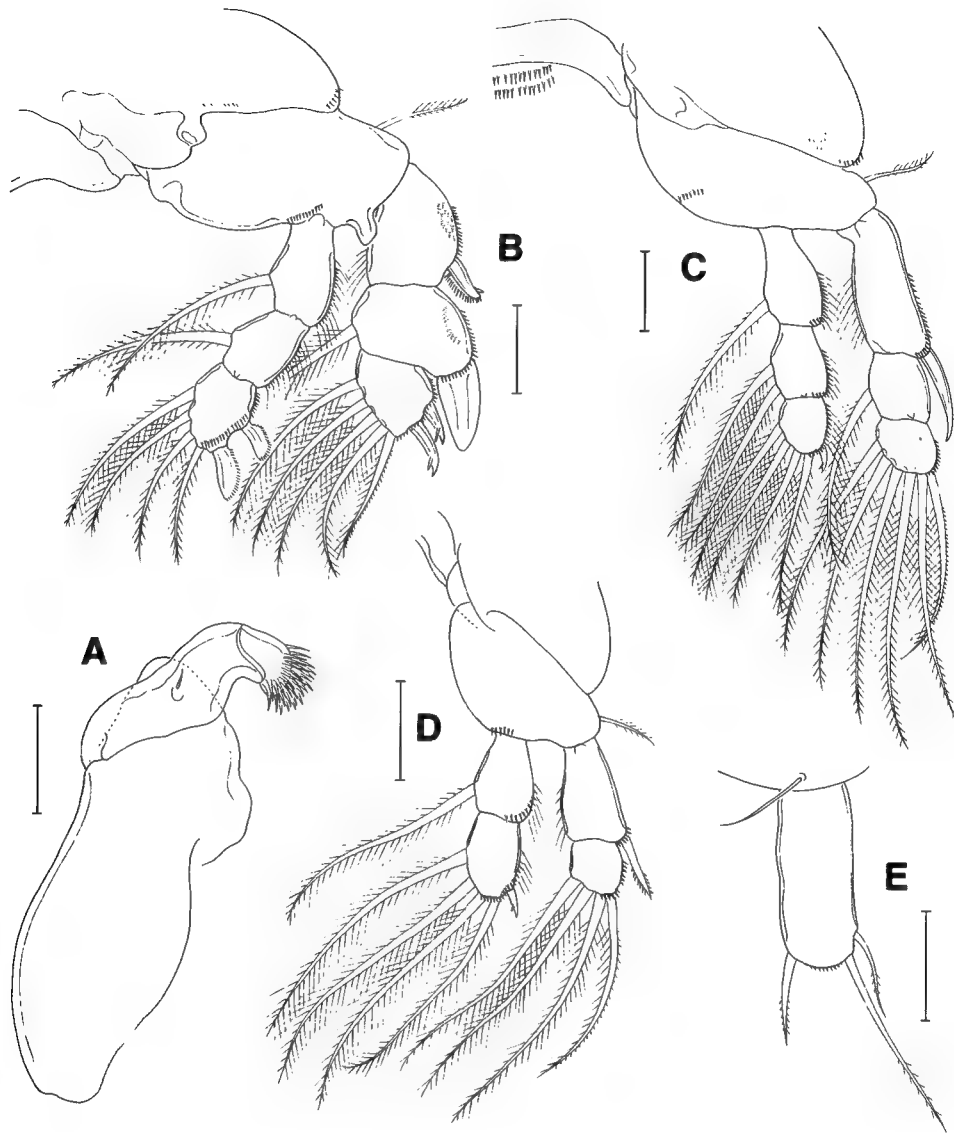
**Female.** Body (Fig. 15A) narrow,  $706 \mu\text{m}$  long. Cephalothorax anteriorly tapering,  $388 \times 215 \mu\text{m}$ , not inflated, with truncate apex. Distinction between metasomites clear. Urosome (Fig. 15B) 5-segmented. Genital double-somite  $55 \times 59 \mu\text{m}$ , with gently rounded lateral margins and row of minute spinules in middle of ventral surface and posteroventral border (Fig. 15C). Three abdominal somites  $18 \times 42$ ,  $15 \times 41$ , and  $21 \times 40 \mu\text{m}$ , respectively, each with row of spinules along posteroventral border. Anal somite deeply incised posteromedially. Caudal ramus  $26 \times 16 \mu\text{m}$  (ratio 1.63 : 1), with 4 caudal setae and spinules near base of each smaller 2 caudal setae. Egg sac variable in size,  $397 \times 126 \mu\text{m}$  in dissected specimen.

Antennule (Fig. 15D) 6-segmented and  $155 \mu\text{m}$  long; armature formula 3, 13, 6, 4+1 aesthetasc, 2+1 aesthetasc, and 7+1 aesthetasc. Antenna (Fig. 15E) slender; first segment about  $58 \times 35 \mu\text{m}$ , with 1 large, scalpel-like distal seta; second segment  $66 \times 29 \mu\text{m}$ , with 1 small seta at





**Fig. 15.** *Neoergasilus angustus* n. sp., female. A, habitus, dorsal; B, urosome, dorsal; C, genital double-somite and abdomen, ventral; D, antennule; E, antenna; F, labrum; G, mandible; H, maxillae. Scales: A, 0.1 mm; B-H, 0.02 mm.



**Fig. 16.** *Neoergasilus angustus* n. sp., female. A, maxilla; B, leg 1; C, leg 2; D, leg 4; E, leg 5. Scales: 0.02 mm for all.

distal 1/4 of inner margin; third segment tapering, strongly curved, 79  $\mu$ m long; terminal claw long and slender, 64  $\mu$ m long, with 1 small proximal seta.

Labrum (Fig. 15F) with pointed posterolateral corners and linear posterior margin. Mandible (Fig. 15G) with 2 spinulated blades. Maxillule (Fig. 15H) armed with 2 terminal setae and 1 inner tapering process. Maxilla (Fig. 16A) 2-segmented; first segment unarmed; second segment with 1 small proximal seta and blunt tip armed with spinules.

Legs 1-3 with 3-segmented exopod and endopod (Fig. 16B, C). Leg 4 (Fig. 16D) with 2-

segmented exopod and endopod. Leg 1 (Fig. 16B) with 1 prominent process on posterior margin of basis between rami; outer spine on second exopodal segment enlarged, plate-like, extending beyond tip of third segment; spines on first and third segments with sub-terminal flagellum. Outer spine on first exopodal segment of leg 2 elongate, extending to middle of third segment. Outer spine on first exopodal segment of leg 4 long, extending slightly over distal margin of second segment. Armature formula of legs 1-4 as follows:

Leg 1:	coxa 0-0;	basis 1-0;	exp. I-0; I-1; II, 5;	enp. 0-1; 0-1; II, 4.
Legs 2 & 3:	coxa 0-0;	basis 1-0;	exp. I-0; 0-1; 6;	enp. 0-1; 0-2; I, 4.
Leg 4:	coxa 0-0;	basis 1-0;	exp. I-0; 4;	enp. 0-1; I, 4.

Leg 5 (Fig. 16E) represented by 1 seta on dorsolateral seta of fifth pedigerous somite and free segment; free segment nearly rectangular,  $42 \times 14 \mu\text{m}$  (ratio 3.0 : 1), with minute spinules on posterior margin and 2 terminal (46 and  $21 \mu\text{m}$ , ventral and dorsal ones, respectively) and 1 subterminal ( $21 \mu\text{m}$ ) setae. Leg 6 absent.

**Male.** Undiscovered.

**Etymology.** The specific name *angustus* ("narrow" in Latin) alludes the relatively narrow body of the new species.

**Remarks.** Of the species assigned to the genus *Ergasilus*, *E. spinipes* described by Byrnes (1986) is apparently a member of *Neoergasilus*. Like the species of *Neoergasilus*, this Australian species has the enlarged outer spine on the second exopodal segment of leg 1, and the slender and strongly curved antenna.

Two of the known species of *Neoergasilus*, *N. ferozepurensis* described by Kumari, Kehera and Gupta (1988) from India and *E. spinipes* (Byrnes, 1986), have the 2-segmented rami on leg 4, as *N. angustus*. But they show the different setation of the same leg: there are 4 and 5 setae respectively on the terminal segments of the exopod and endopod in *N. angustus*, in contrast to 4 and 4 in *N. ferozepurensis* or 5 and 6 in *N. spinipes*.

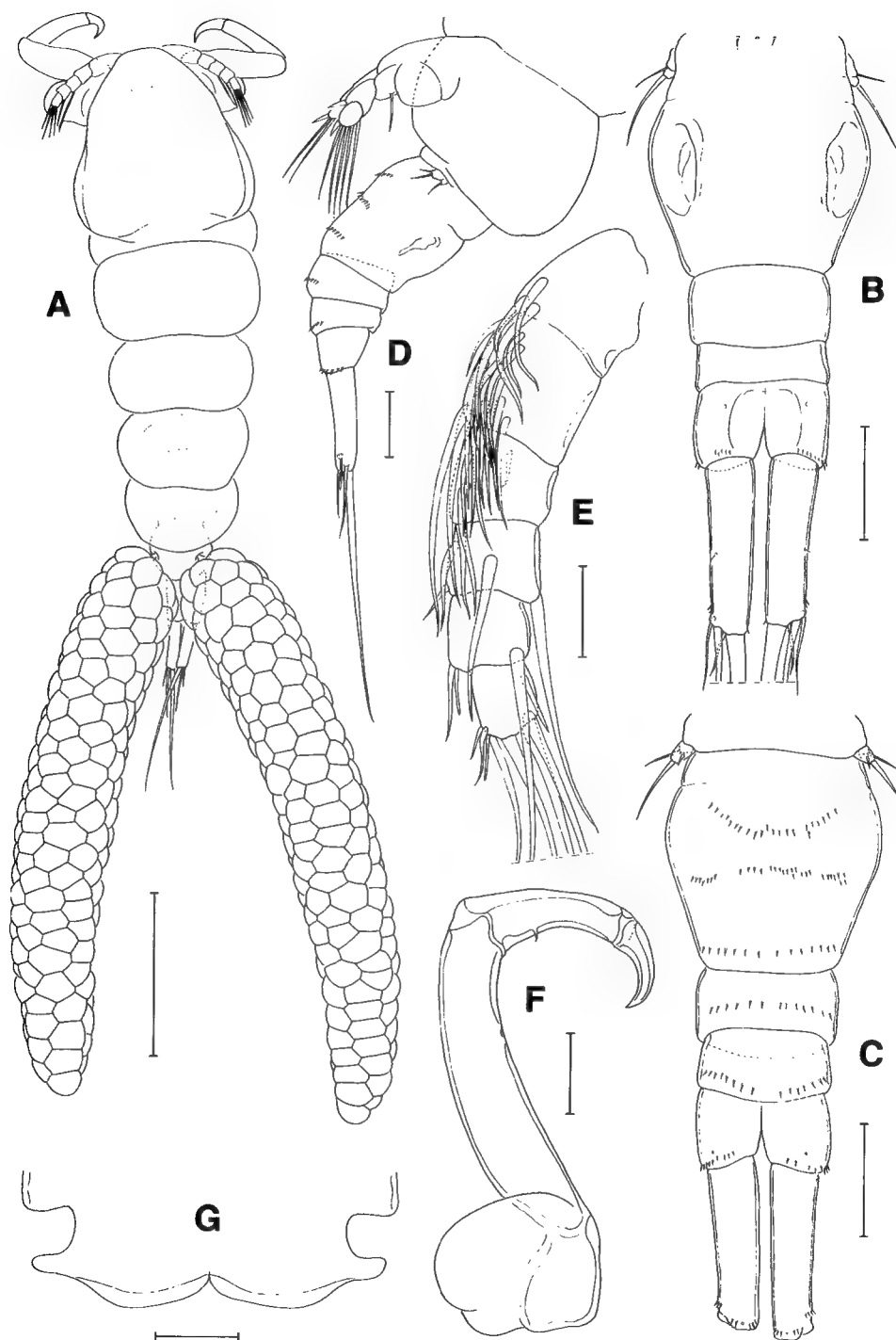
Although *Neoergasilus angustus* is similar in body form to *N. japonicus*, it is clearly distinguishable from the latter by having the shorter caudal rami, the only a single seta (3 setae in *E. japonicus*) on the first antennal segment, and, as mentioned above, the 2-segmented (1-segmented in *E. japonicus*) rami of leg 4.

Genus *Sinergasilus* Yin, 1949 중국낚벌레속 (신칭)

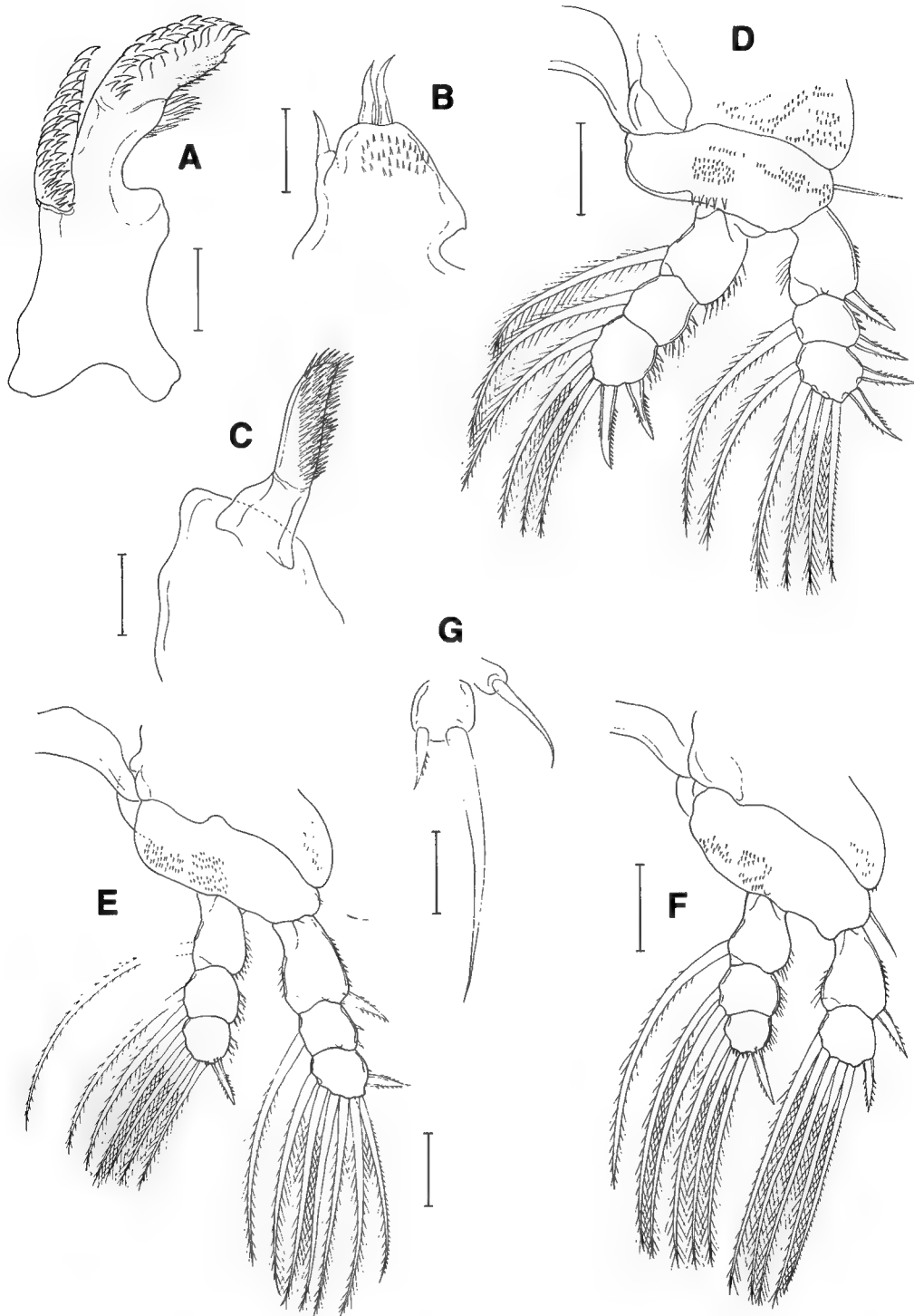
***Sinergasilus undulatus* (Markewitsch, 1940) 키다리중국낚벌레 (신칭) (Figs. 17 and 18)**

**Material examined.** 1♀ removed from gill of *Carassius auratus* from Deogwoo Reservoir in Paltan-myeon, Suweon ( $37^{\circ} 10' \text{N}$ ,  $126^{\circ} 56' \text{E}$ ), 30 July 2002.

**Female.** Body (Fig. 17A) narrow, not inflated, weakly tapering, 1.96 mm long, with clear segmentation. Cephalosome well defined from first pedigerous somites, roughly triangular, and  $62 \times 56 \mu\text{m}$ . Four metasomites well defined from each other, each with round lateral margins and  $25 \times 52$ ,  $22 \times 45$ ,  $23 \times 41$ , and  $23 \times 35 \mu\text{m}$ , respectively. Urosome (Fig. 17B, C) 5-segmented, about 1/3 as long as prosome, curved upward (Fig. 17D). Fifth pedigerous somite approximately  $52 \times 162 \mu\text{m}$ . Genital double-somite  $158 \times 196 \mu\text{m}$ , with roundly convex lateral margins and 3 rows of spinules on ventral surface, including one row along posteroventral border. Three abdominal



**Fig. 17.** *Sinergasilus undulatus* (Markewitsch), female. A, habitus, dorsal; B, urosome, dorsal; C, same, ventral; D, fourth pedigerous somite and urosome, lateral; E, antennule; F, antenna; G, labrum. Scales: A, 0.5 mm; B-D, F, 0.1 mm; E, G, 0.05 mm.



**Fig. 18.** *Sinergasilus undulatus* (Markewitsch), female. A, mandible; B, maxillule; C, maxilla; D, leg 1; E, leg 2; F, leg 4; G, leg 5. Scales: A-C, G, 0.02 mm; D-F, 0.05 mm.

somites  $63 \times 125$ ,  $41 \times 117$ , and  $71 \times 119 \mu\text{m}$ , respectively, each with row of spinules along posteroventral border. Anal somite deeply incised posteromedially. Caudal ramus  $156 \times 42 \mu\text{m}$  (ratio 3.71 : 1), with 4 caudal setae and several spinules on posteroventral area. Egg sac long, cylindrical,  $1.83 \times 0.30 \text{ mm}$  in dissected specimen (Fig. 17A).

Antennule (Fig. 17E) 6-segmented and  $282 \mu\text{m}$  long; setae aggregated; first segment with 3 setae; terminal 3 segments with 4 setae, 2 setae and 1 aesthetasc, and 7 setae and 1 aesthetasc, respectively; number of setae on second and third segments unclear. Antenna (Fig. 17F) slender and 4-segmented; first segment shorter than long, approximately  $125 \times 207 \mu\text{m}$ , with prominent outer expansion wider than segment itself; second segment more than 4 times as long as wide,  $383 \times 90 \mu\text{m}$ , and unarmed; third segment tapering,  $167 \mu\text{m}$  long, with small seta at proximal 1/3 of inner margin; terminal claw short,  $106 \mu\text{m}$  long, and strongly curved distally.

Labrum (Fig. 17G) with prominent posterolateral processes and weak posteromedian incision. Mandible (Fig. 18A) with 2 blades and tuft of spinules on anterior margin near base of distal blade. Maxillule (Fig. 18B) with 2 terminal setae, 1 subterminal, seta-like process, and many sub-distal spinules; outer margin distinctly projected, with angular tip. Maxilla (Fig. 18C) 2-segmented; first segment unarmed; second segment spinulated in distal half.

Legs 1-3 with 3-segmented exopod and endopod (Fig. 18D, E). Leg 4 (Fig. 18F) with 2-segmented exopod and 3-segmented endopod. All these legs with patches of spinules on coxa and basis. Armature formula of legs 1-4 as follows:

Leg 1:	coxa 0-0;	basis 1-0;	exp. I-0; I-1; II, 5;	enp. 0-1; 0-1; II, 4.
Legs 2 & 3:	coxa 0-0;	basis 1-0;	exp. I-0; 0-1; I, 6;	enp. 0-1; 0-2; I, 4.
Leg 4:	coxa 0-0;	basis 1-0;	exp. I-0; I, 5;	enp. 0-1; 0-2; I, 3.

Leg 5 (Fig. 18G) consisting of free segment and 1 nearby seta based on papilla; free segment small, as long as wide, with 2 unequal setae ( $68$  and  $15 \mu\text{m}$  long, respectively). Leg 6 absent.

**Male.** Undiscovered.

**Remarks.** This species is represented by only a single female in this study. With the relatively large body, this copepod permits the easy discovery on the host. In Amur River, this copepod was found to parasitize the fishes of the genera *Hypophthalmichthys*, *Carassius*, *Cyprinus*, *Elopichthys* and *Siniperca* (Dogiel and Akhmerov, 1952).

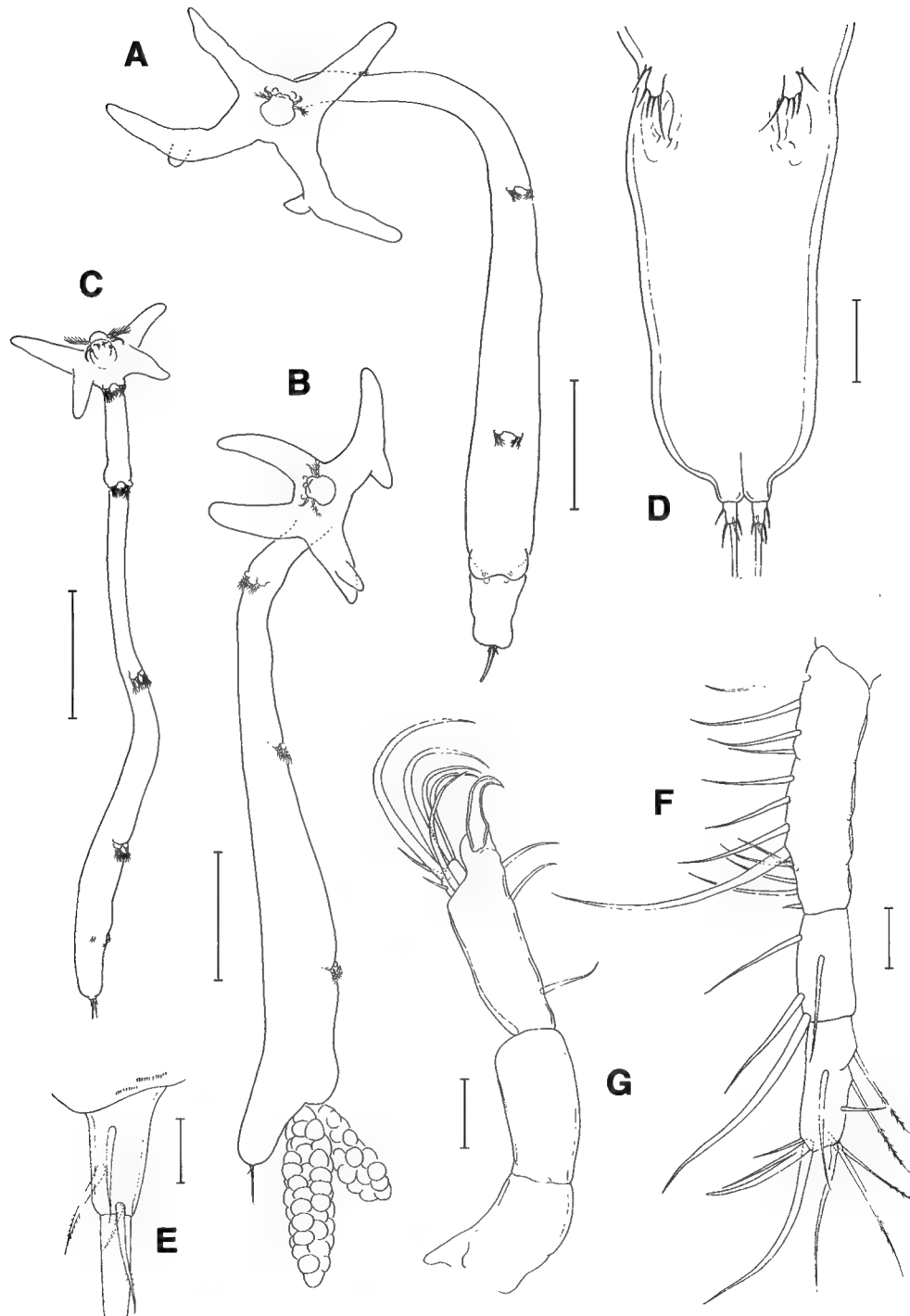
Order Cyclopoida 김물벼룩목

Family Lernaevidae 닳벌레과 (개칭)

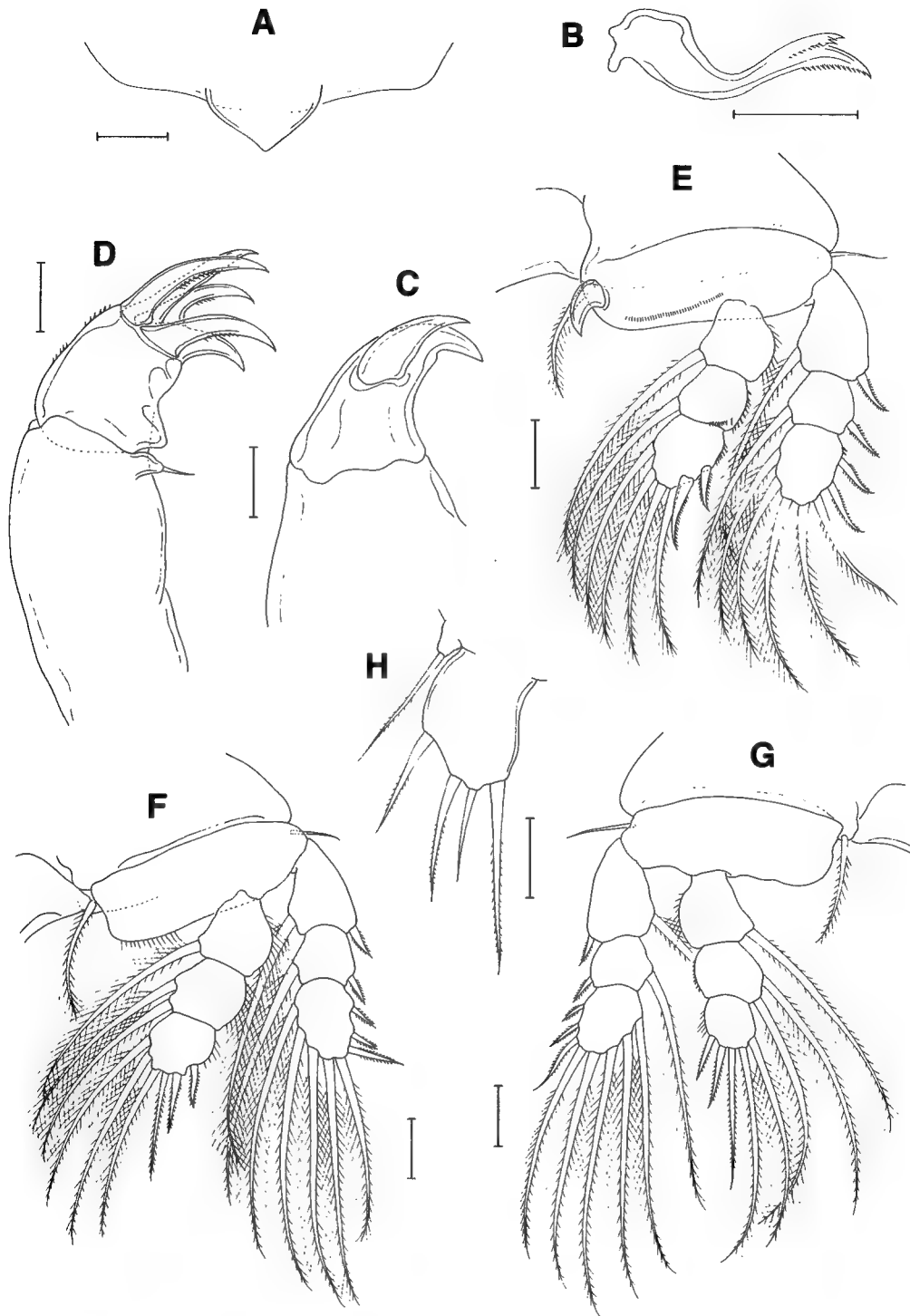
Genus *Lernaea* L., 1758 닳벌레속 (개칭)

***Lernaea cyprinacea* L., 1758 닳벌레 (개칭) (Figs. 19 and 20)**

**Material examined.** 1) from *Carassius auratus*: 1 ♀ (from skin) from Jookheon Reservoir in Kangnung ( $37^{\circ}47'N$ ,  $128^{\circ}52'E$ ), 11 July 2002. 2) from *Pseudorasbora parva*: 1 ♀ (from skin) from Jookheon Reservoir in Kangnung, 11 July 2002; 12 ♀♀ (from skin) from Jookheon Reservoir in Kangnung, 24 July 2002; 1 ♀ (from skin) from Gasan Reservoir in Boobook-myeon, Milyang, Kyeongnam ( $35^{\circ}32'N$ ,  $128^{\circ}42'E$ ), 5 August 2002. 3) from *Zacco platypus*: 1 ♀ (from skin) from Sinpoong Reservoir in Jibo-myeon, Andong, Kyeongbook ( $36^{\circ}32'N$ ,  $128^{\circ}26'E$ ), 3 August 2002; 4) from *Lepomis macrochirus*: 5 ♀♀ (from skin) from Gobok reservoir in Seo-



**Fig. 19.** *Lerna cyprinacea* L., female. A, B, habitus of fully grown adult; C, habitus of young adult; D, posterior part of body, ventral; E, caudal ramus, outer lateral; F, antennule; G, antenna. Scales: A-C, 1 mm; D, 0.1 mm; E-G, 0.02 mm.



**Fig. 20.** *Lernaea cyprinacea* L., female. A, labrum; B, mandible; C, maxilla; D, maxilliped; E, leg 1; F, leg 2; G, leg 4; H, leg 5. Scales: 0.02 mm for all.



myeon, Yeonki-gun, Choongnam (36° 36'N, 127° 14'E), 31 July 2002. 5) from *Channa arga*: 3 ♀♀ (from fins) from Imha lake in Andong, Kyeongbook (36° 31'N, 128° 53'E), 4 August 2002. 6) from *Cyprinus carpio*: 9 ♀♀ (from fins) from the same locality, on same date. 7) from *Hemiculter eigenmanni*: 1 ♀ (from fin) from Gokgyo Stream in Silok-dong, Asan, Choongnam (36° 48'N, 126° 58'E), 30 July 2002; 8) from *Micropterus salmoides*: 2 ♀♀ (from fins) from Daeyool Reservoir in Kumgoo-myeon, Kimje (35° 47'N, 127° 02'E), 8 August 2002.

**Female.** Body (Fig. 19A) 6.15 mm long in largest specimen, with holdfast arranged in lateral plane. Cephalosome small, bearing antennae and mouthparts. Holdfast consisting of anterior and posterior pairs of processes; posterior pair longer than anterior pair and branched in fully grown adults (Fig. 19A, B). Trunk cylindrical, with nearly parallel margins (in young adult) or gradually broadened distally (in grown adult). Abdomen (Fig. 19D) longer than wide. Caudal ramus (Fig. 19E) longer than wide (38 × 25 μm), with 4 small and 1 long terminal setae.

Antennule (Fig. 19F) 3-segmented, with armature formula 13, 4, and 11 setae. Antenna (Fig. 19G) 3-segmented; first and second segments unarmed; terminal segment armed with 3 setae on inner margin, and distally 7 setae and 1 claw. Labrum (Fig. 20A) with triangular process on posterior margin. Mandible (Fig. 20B) minute, distally bifurcate. Maxilla (Fig. 20C) 2-segmented; basal segment unarmed; terminal segment being strong claw, with large secondary claw in middle. Maxilliped (Fig. 20D) 2-segmented; basal segment with 1 distal seta based on papilla; terminal segment with blunt proximal process on inner margin and 5 terminal claws.

Legs 1-4 with 3-segmented exopod and endopod (Fig. 20E-G). Armature formula of legs 1-4 as follows:

Leg 1:	coxa 0-1;	basis 1-I;	exp. I-1; I-1; II, 5;	enp. 0-1; 0-1; II, 4.
Legs 2 & 3:	coxa 0-1;	basis 1-0;	exp. I-1; I-1; III, 5;	enp. 0-1; 0-2; II, 4.
Leg 4:	coxa 0-1;	basis 1-0;	exp. I-1; I-1; III, 5;	enp. 0-1; 0-2; II, 3.

Leg 5 (Fig. 20H) represented by 1 seta on papilla and subquadrate segment bearing 4 distal setae. Leg 6 not seen.

**Male.** Undiscovered.

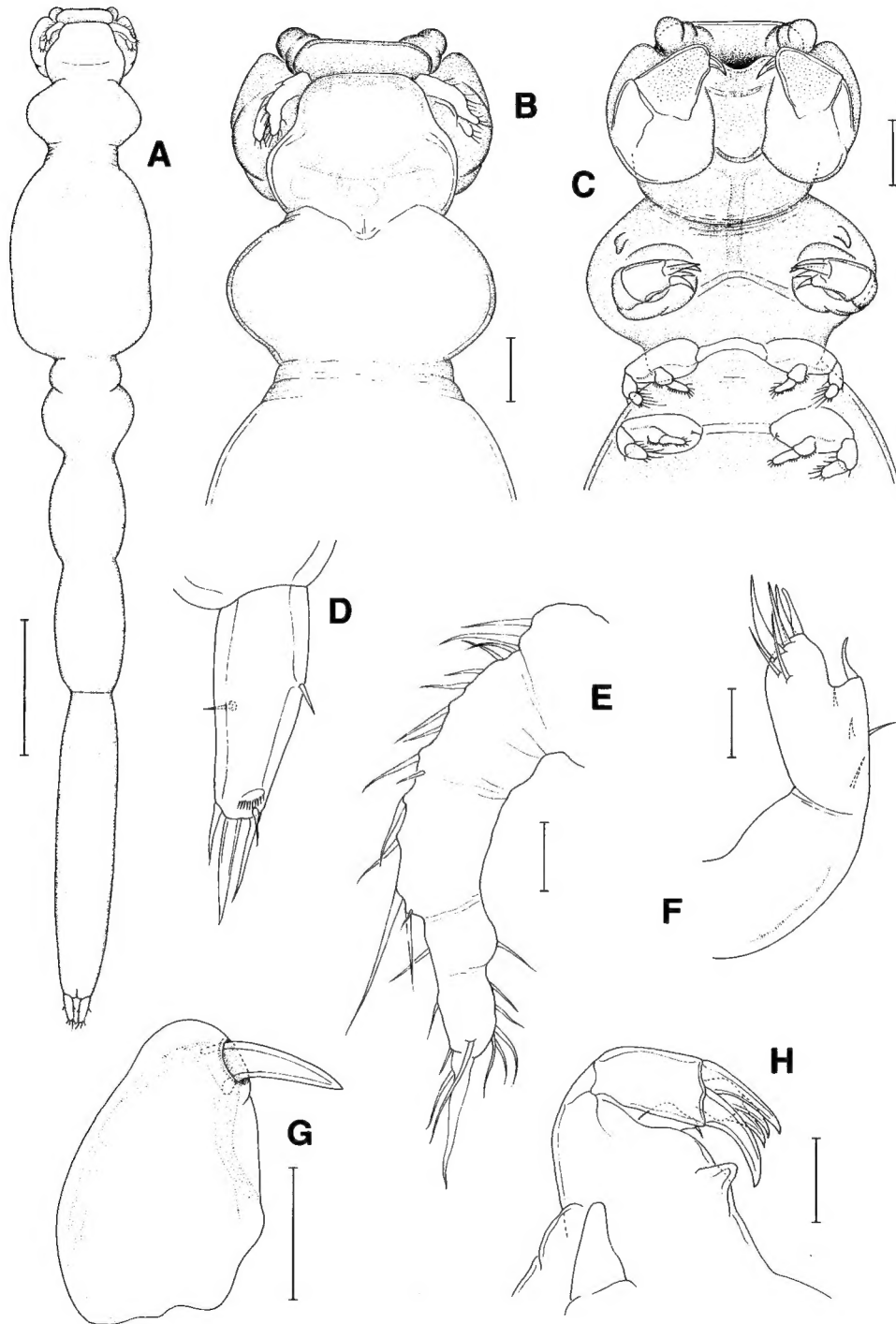
**Remarks.** This cosmopolitan species is the first known copepod parasite of Korean freshwater fishes. It was recorded as *Lernaea elegans* Leigh-Sharpe by Honta (1939) who collected it from the fish *Misgurnus anguillicaudatus* (Cantor). *Lernaea elegans* is, however, being treated as a synonym of *L. cyprinacea*. Eight species of freshwater fishes are found to harbor this copepod, of which *Micropterus salmoides* and *Lepomis macrochirus* are the non-indigenous fishes of Korea.

Genus *Lamproglena* Nordmann, 1832 민물아가미불게속

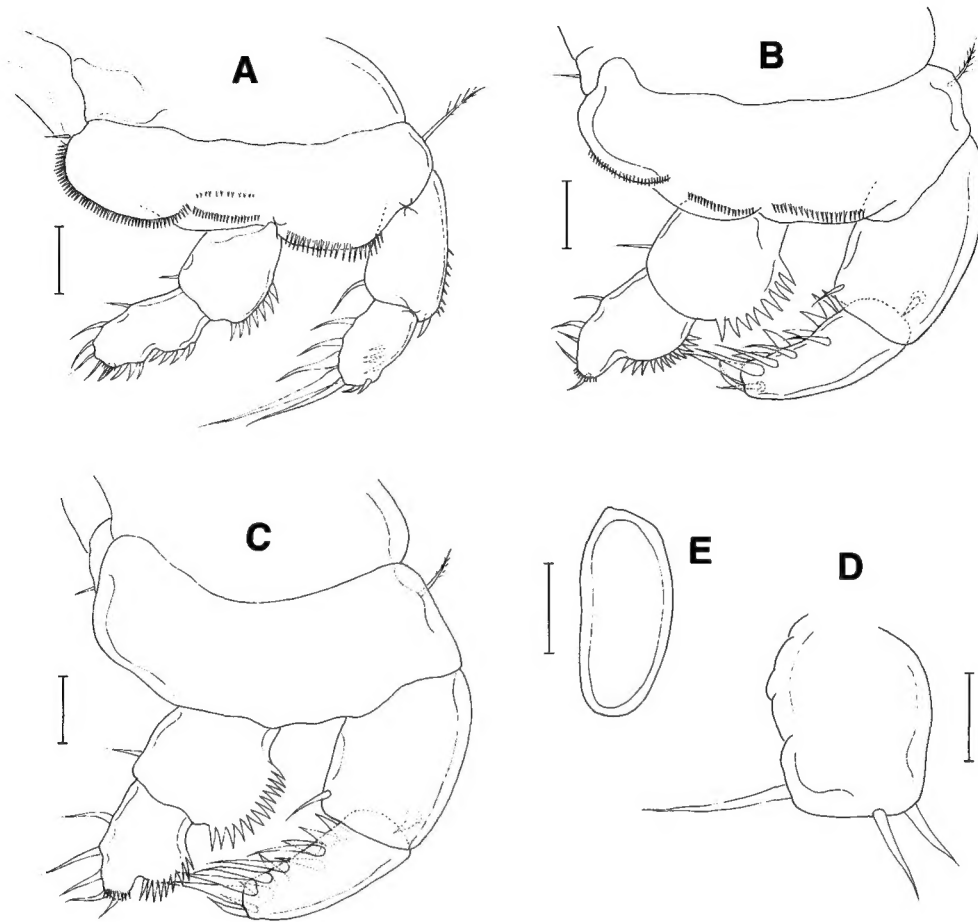
***Lamproglenna chinensis* Yü, 1937 중국민물아가미불게 (Figs. 21 and 22)**

**Material examined.** 3 ♀♀ from Gills of *Channa arga* from Imha Lake in Andong, Kyeongbook (36° 31'N, 128° 53'E), 4 August 2002.

**Female.** Body (Fig. 21A) elongated, 3.64 mm long, consisting of cephalon, neck, trunk, fifth pedigerous somite, genital double-somite, and 3-segmented abdomen. Cephalon 271 × 404 μm with dorsal shield of 300 μm wide, with antennule and antenna visible in dorsal view (Fig. 21B). Neck roundly expanded laterally, containing maxillipeds, pre-maxillipedal processes and legs 1 (Fig.



**Fig. 21.** *Lamproglana chinensis* Yü, female. A, habitus, dorsal; B, anterior part of body, dorsal; C, same, ventral; D, caudal ramus; E, antennule; F, antenna; G, maxilla; H, maxilliped. Scales: A, 0.5 mm; B, C, 0.1 mm; D, G, H, 0.05 mm; E, 0.02 mm; F, 0.2 mm.



**Fig. 22.** *Lamproglena chinensis* Yü, female. A, leg 1; B, leg 3; C, leg 4; D, leg 5; E, spermatophore. Scales: A-C, D, 0.02 mm; E, 0.05 mm.

21C). Trunk  $715 \times 508 \mu\text{m}$ , consisting of fused second to fourth pedigerous somites. Fifth pedigerous somite  $110 \times 260 \mu\text{m}$ , short and narrow. Genital double-somite spherical,  $250 \times 333 \mu\text{m}$ . Three abdominal somites delimited from each others by lateral constrictions,  $383 \times 280$ ,  $458 \times 250$ , and  $1083 \times 208 \mu\text{m}$ , respectively. Caudal ramus tapering,  $86 \times 37 \mu\text{m}$ , armed with 4 terminal and 2 lateral setae; largest one of terminal setae thick,  $40 \mu\text{m}$  long.

Antennule (Fig. 21E)  $135 \mu\text{m}$  long, unsegmented, armed with 26 setae, terminal one of them enlarged. Antenna (Fig. 21F) incompletely 2-segmented; basal segment unarmed; distal segment armed with 5 setae on inner surface and 6 terminal setae. Maxilla (Fig. 21G) 1-segmented and tipped with claw. Maxilliped (Fig. 21H) 2-segmented; basal segment with pointed process on inner margin and distal, seta-tipped process; distal segment with 4 terminal claws.

Legs 1-4 with 2-segmented exopod and endopod (Fig. 22A-C). Basis of legs 1-4 with posterior margin rimmed with spinules. Outer margin of endopod of legs 1-4 dentate. Distal exopodal

segment of legs 1-4 with several spine-like spinules (or denticles). Armature formula as follows:

Legs 1 & 2:	coxa 0-1;	basis 1-0;	exp. I-1; II, 5;	enp. 0-1; I, 5.
Legs 3 & 4:	coxa 0-1;	basis 1-0;	exp. I-1; II, 5;	enp. 0-1; 5.

Leg 5 (Fig. 22D) nearly quadrangular,  $47 \times 36 \mu\text{m}$ , armed with 3 distal setae, longest one of them separated from other two. Leg 6 not seen. Spermatophore removed from female (Fig. 22E) ovoid,  $117 \times 51 \mu\text{m}$ .

**Male.** Undiscovered.

**Remarks.** In Korea, Kim (1998) reported previously this copepod from the fish *Channa arga*. This copepod seems quite host-specific, since up to date no other Korean fishes has been found to be infested by this copepod. Ho and Kim's (1997) record on this species from Thailand appears to be different from our specimens. Since the illustrations in the original description made by Yü (1937) are not so detailed, we can hardly decide which one is real *L. chinensis*.

## ACKNOWLEDGEMENT

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## 한국산 담수 어류에 기생하는 요각류

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## 요 약

17종의 한국산 담수 어류로부터 5속 12종의 기생성 요각류가 발견되었다. 이들은 피라미낫벌레 (*Ergasilus coniforemis* n. sp.), 배불뚝낫벌레 (*Ergasilus ventriosus* n. sp.), 장구머리낫벌레 (*E. briani* Markewitsch), 쏘가리낫벌레 (*E. peregrinus* Heller), 풍선신낫벌레 (*Neoergasilus inflatus* Yin), 일본신낫벌레 [*Neoergasilus japonicus* (Harada)], 큰가시신낫벌레 (*N. longispinosus* Yin), 뚱보신낫벌레 (*N. bullatus* n. sp.), 홀쭉신낫벌레 (*N. angustus* n. sp.), 키다리중국낫벌레 [*Sinergasilus undulatus* (Markewitsch)], 닳벌레 (*Lernaea cyprinacea* L.), 중국민물아가미불게 (*Lamproglena chinensis* Yü)이다. 일본신낫벌레는 한국에서 가장 흔한 담수어류 기생성 갑각류로서 10종의 담수어류에 기생하는 것이 발견되었다. 또한, 피라미는 한국에서 가장 다양한 갑각류가 기생하는 숙주로서, 7종의 요각류가 이 어류에 기생하는 것이 발견되었다. 발견된 기생성 갑각류 중에서 신종과 한국 미기록종을 기재하였다. 과거에 기재가 불완전하게 이루어진 중국민물아가미불게도 재기재하였다.